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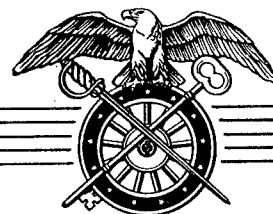
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THE APPLIED ENVIRONMENTAL RESEARCH PROGRAM  
OF THE  
DEPARTMENT OF THE ARMY

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ANNUAL REPORT

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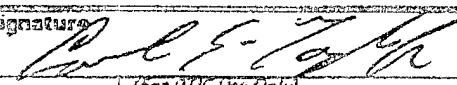


QUARTERMASTER RESEARCH & ENGINEERING COMMAND  
JUNE 1960  
NATICK, MASSACHUSETTS

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OFFICE OF THE QUARTERMASTER GENERAL  
DEPARTMENT OF THE ARMY

THE APPLIED ENVIRONMENTAL RESEARCH PROGRAM  
OF THE  
DEPARTMENT OF THE ARMY  
ANNUAL REPORT

JUNE 1960  
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## FOREWORD

THIS REPORT, PREPARED BY THE U.S. ARMY QUARTERMASTER CORPS, IS THE SIXTH IN A SERIES OF ANNUAL REPORTS, PRESENTING INFORMATION ON THE STATUS OF APPLIED ENVIRONMENTAL RESEARCH WITHIN THE DEPARTMENT OF THE ARMY. ACCOMPLISHMENTS ACHIEVED DURING THE PERIOD 10 JUNE 1959 TO 10 JUNE 1960 ARE SUMMARIZED IN FULFILLMENT OF RESPONSIBILITY FOR PRIMARY COGNIZANCE FOR RESEARCH AND DEVELOPMENT IN THE FIELD OF APPLIED ENVIRONMENTAL RESEARCH, ASSIGNED TO THE QUARTERMASTER GENERAL BY DEPARTMENT OF THE ARMY MEMORANDUM, 10 JUNE 1949, FILE CSGLD/F1 28507, SUBJECT: ASSIGNMENT OF RESEARCH AND DEVELOPMENT COGNIZANCE IN THE FIELDS OF CRYOLOGICAL PHENOMENA, METEOROLOGY, AND ENVIRONMENTAL RESEARCH (APPENDIX 1), AND EXTENDED BY D/F, 30 JUNE 1952, FILE G4/F2 41949, SUBJECT: TRANSFER OF SIX ARMY-WIDE ENVIRONMENTAL RESEARCH PROJECTS TO THE QUARTERMASTER GENERAL (APPENDIX 2).

THE ASSISTANCE OF THE CHEMICAL CORPS, CORPS OF ENGINEERS, ORDNANCE CORPS, ARMY MEDICAL SERVICE, SIGNAL CORPS, AND TRANSPORTATION CORPS IS GRATEFULLY ACKNOWLEDGED.

## SUMMARY

ENVIRONMENTAL RESEARCH CONDUCTED WITHIN THE DEPARTMENT OF THE ARMY DURING FISCAL YEAR 1960 YIELDED AN INCREASING AMOUNT OF KNOWLEDGE ON THE NATURE OF THE ENVIRONMENT AND ITS EFFECTS UPON MAN AND MATERIEL. NOT ONLY WAS NOTABLE PROGRESS MADE IN AREAS OF RESEARCH WHICH ARE OF A CONTINUING NATURE, BUT EFFORTS WERE ALSO EXTENDED TO NEW FRONTIERS IN ENVIRONMENTAL SCIENCE.

### SIGNIFICANT ACCOMPLISHMENTS OF THE PAST YEAR INCLUDE:

1. PROGRESS TOWARD DEFENSE-WIDE UNIFORMITY IN THE SELECTION OF ENVIRONMENTAL CRITERIA FOR THE DESIGN, DEVELOPMENT, AND TESTING OF MILITARY EQUIPMENT AND MATERIEL; DEVELOPMENT OF A DOD ENGINEERING GUIDANCE DOCUMENT; AND THE INITIATION OF A SERIES OF ENVIRONMENTAL HANDBOOKS. (QUARTERMASTER AND OTHER TECHNICAL SERVICES)
2. SUCCESSFUL COMPLETION OF A TRACTOR-SLED RESEARCH EXPEDITION IN NORTHERN GREENLAND (LEAD DOG 59). (TRANSPORTATION, JOINED BY FIVE ARMY R&D AGENCIES)
3. CONTINUATION OF THE OPERATION OF METEOROLOGICAL NETWORKS TO COLLECT DATA IN SUPPORT OF THE ENVIRONMENTAL RESEARCH PROGRAMS OF THE VARIOUS TECHNICAL SERVICES. (SIGNAL)
4. DEVELOPMENT OF A TECHNIQUE TO MEASURE THE DUST PRODUCING CAPABILITY OF SOIL. (ORDNANCE)
5. DEVELOPMENT OF A TECHNIQUE FOR THE OBJECTIVE AND PRECISE EVALUATION OF THE RELATIVE TOPOGRAPHIC RELIEF REPRESENTATIVE OF THE VICINITY OF ANY GIVEN POINT, INCLUDING WIDTHS OF ASSOCIATED VALLEYS. (QUARTERMASTER)
6. IN COOPERATION WITH OTHER MILITARY AND CIVILIAN AGENCIES, INITIATED THE OPERATION OF A METEOROLOGICAL ROCKET NETWORK DESIGNED TO COLLECT METEOROLOGICAL DATA IN THE LAYER OF THE ATMOSPHERE IN WHICH NORMAL BALLOON AND SATELLITE SOUNDINGS ARE NOT MADE. (SIGNAL)
7. INVESTIGATION OF THE FREEZE-THAW PHENOMENON AS AN INDEX TO CLIMATIC STRESS AS APPLIED TO CLOTHING, FOOD, STORAGE, AND PERSONAL EQUIPMENT. (QUARTERMASTER)
8. DEVELOPMENT OF A MATHEMATICAL MODEL FOR PREDICTING LINE-OF-SIGHT INFORMATION. (QUARTERMASTER)
9. PROGRESS IN THE DEVELOPMENT OF IMPROVED OPERATIONAL CONCEPTS AND DOCTRINE BASED UPON OBSERVATIONAL DATA OF THE EFFECTS OF ENVIRONMENTAL CONDITIONS IN THE MAJOR WORLD ENVIRONMENTS UPON CHEMICAL CORPS ITEMS AND SYSTEMS. (CHEMICAL)

10. DEVELOPMENT AND STANDARDIZATION OF INSTRUMENTS FOR CONTACT MEASUREMENT OF SOIL TRAFFICABILITY. (ENGINEERS)

11. PROGRESS IN THE ADVANCEMENT OF KNOWLEDGE OF ARCTIC METEOROLOGY, AND INITIATION OF A PROGRAM FOR TROPICAL METEOROLOGICAL RESEARCH. (SIGNAL)

12. PARTICIPATION IN ANTARCTIC FIELD WORK TO STUDY AERONAUTICAL AND NAVIGATIONAL OPERATION IN COMPARISON WITH THOSE PRACTICED BY THE NAVY. (TRANSPORTATION)

13. DEMONSTRATION OF INCREASED PHYSIOLOGICAL RESISTANCE TO COLD INJURY IN MAN AFTER ACCLIMATIZATION TO LOW TEMPERATURES. (MEDICAL)

14. PROGRESS IN BETTER UNDERSTANDING OF WHITEOUT CONDITIONS IN POLAR AREAS. (ORDNANCE)

15. COMPLETION OF ANALOG STUDIES COMPARING THE CLIMATES OF INDONESIA, THE PHILIPPINES, AND BORNEO; AUSTRALIA AND NEW GUINEA; THE FAR EAST; AND THE PACIFIC ISLANDS WITH THAT OF THE PANAMA CANAL ZONE. (ENGINEER AND QUARTERMASTER)

16. CONTINUATION OF THE COLLECTION OF SOLAR AND TERRESTRIAL RADIANT ENERGY DATA AND PROGRESS IN THE DEVELOPMENT OF A METHOD TO PREDICT HOURLY SOLAR RADIATION VALUES FROM DAILY RADIATION TOTALS. (QUARTERMASTER AND SIGNAL)

17. PREPARATION AND MAINTENANCE OF ENVIRONMENTAL FACTORS INDEX AND CHARTS SUMMARIZING RESULTS OF ORDNANCE CORPS ENVIRONMENTAL TESTS IN ADVERSE ENVIRONMENTS. (ORDNANCE)

18. TABULATIONS AND PUBLICATION OF TEMPERATURE AND WINDSPEED FREQUENCY DATA BY 5 F° INTERVALS FOR OVER 200 REPRESENTATIVE STATIONS IN NORTHERN EUROPE AND ASIA. (QUARTERMASTER)

19. COMPLETION OF INSECT DISTRIBUTION STUDIES FOR AFRICA. (QUARTERMASTER)

20. CONTINUED PROGRESS IN THE ANALYSIS AND INTERPRETATION OF MICROCLIMATIC DATA FROM SELECTED ARMY TEST SITES. (SIGNAL AND QUARTERMASTER)

21. CONTINUATION OF THE ENVIRONMENTAL TESTING OF CHEMICAL CORPS ITEMS TO ESTABLISH THEIR PERFORMANCE AND STORAGE CAPABILITIES IN THE FIVE MAJOR TYPES OF WORLD ENVIRONMENTS. (CHEMICAL)

22. PROGRESS IN THE DETERMINATION OF ABRASIVE ACTION OF WORLD-WIDE SOILS UPON THE TRACTION OF VEHICULAR EQUIPMENT. (ORDNANCE)

23. DEVELOPMENT OF A NOMOGRAPHIC METHOD, ADAPTABLE TO MACHINE COMPUTATION, FOR PREDICTING DAILY MINIMUM TEMPERATURES FROM MEAN DAILY MINIMUM AND MONTHLY EXTREME DATA. (QUARTERMASTER)

24. CONTINUATION OF ANALOG STUDIES COMPARING TERRAIN IN VARIOUS PARTS OF THE WORLD WITH THAT OF ARMY TEST SITES. (ENGINEERS)

25. COMPLETION OF STUDY OF PETROGRAPHIC AND PARTICLE SIZE CHARACTERISTICS OF SOIL SAMPLES TAKEN FROM DESERT AND TEMPERATE ENVIRONMENTS. (ORDNANCE)

26. EXTENSION OF THE PROCESSING AND STORAGE OF ENVIRONMENTAL INFORMATION ON MAPS AND PUNCH CARDS TO PROVIDE GLOBAL COVERAGE BY DEGREE QUADRANGLE FOR ALL LAND AREAS OF THE EARTH. (QUARTERMASTER)

27. CONTINUATION OF THE DEVELOPMENT OF NEW AND IMPROVED INSTRUMENTATION FOR THE MEASUREMENT OF SUCH METEOROLOGICAL FACTORS AS ATMOSPHERIC PARTICULATE MATTER, DESERT HUMIDITIES, SOIL MOISTURE AND TEMPERATURE, AND OTHERS. (SIGNAL)

28. COMPLETION OF A STUDY ILLUSTRATING THE RELATIONSHIPS BETWEEN THE ENVIRONMENTAL AND MILITARY ACTIVITIES IN SOUTHWEST ASIA; INITIATION OF SIMILAR STUDIES FOR OTHER WORLD AREAS. (QUARTERMASTER)

29. CONTINUATION OF LABORATORY AND FIELD TESTING OF EQUIPMENT IN HOT AND COLD ENVIRONMENTS. (ENGINEERS)

30. COMPLETION OF A STUDY OF THE EFFECTS OF HUMAN ACTIVITIES, INCLUDING MILITARY CAMPAIGNS, UPON THE VEGETATION OF THE MIDDLE APPALACHIAN MOUNTAINS. (QUARTERMASTER)



# THE APPLIED ENVIRONMENTAL RESEARCH PROGRAM OF THE DEPARTMENT OF THE ARMY

## CHAPTER I: INTRODUCTION

APPLIED ENVIRONMENTAL RESEARCH IS DEFINED (IN D/A MEMO 10 JUNE 1949, FILE CSGLD/F1 28507, SUBJECT: ASSIGNMENT OF RESEARCH AND DEVELOPMENT COGNIZANCE IN THE FIELD OF CRYOLOGICAL PHENOMENA, METEOROLOGY, AND ENVIRONMENTAL RESEARCH) AS "THE COLLATION OF STATISTICAL, METEOROLOGICAL, CLIMATIC, AND GEOGRAPHICAL DATA AS ACCUMULATED BY THE RESPONSIBLE AGENCIES, THE INTERPRETATION OF THESE DATA, AND THE PRESENTATION OF THE EVALUATED INFORMATION IN SUITABLE FORM FOR APPLICATION BY APPROPRIATE AGENCIES TO LOGISTICS PROBLEMS OF EQUIPMENT, PERSONNEL AND OPERATIONAL FUNCTIONS."

IN IMPLEMENTING ITS ASSIGNMENT, THE QUARTERMASTER CORPS PLAYS A LEADING ROLE IN THE COORDINATION OF RESEARCH ACTIVITIES WITHIN THE DEPARTMENT OF THE ARMY AND IN LIAISON WITH OTHER ELEMENTS OF THE DEPARTMENT OF DEFENSE. MUCH OF THIS EFFORT IS ACCOMPLISHED THROUGH REPRESENTATION ON ESTABLISHED COMMITTEES AND PANELS, INFORMAL EXCHANGE OF INFORMATION AMONG SCIENTISTS, AND PUBLICATION OF REPORTS.

IMPLEMENTATION OF ONE OF THE TASKS RECOMMENDED IN THE DOD ENGINEERING GUIDANCE PROGRAM IN THE ENVIRONMENTAL FIELD, THAT OF PREPARING A DOD ENVIRONMENTAL HANDBOOK SERIES, WILL BRING TOGETHER IN ONE COMPLETE SOURCE ALL ENVIRONMENTAL DATA AND CRITERIA FOR USE IN GUIDING THE DESIGN, DEVELOPMENT, AND TESTING OF MILITARY MATERIEL. THE MASTER DETAILED OUTLINE OF THIS SERIES HAS BEEN COMPLETED AND PLANS FOR IMPLEMENTATION WITHIN DOD ARE UNDERWAY.

THE ARMY SCIENTIFIC ADVISORY PANEL, ENVIRONMENTAL RESEARCH SUBPANEL, MET THREE TIMES DURING THE PAST YEAR, FROM 5-6 OCTOBER 1959 AT HEADQUARTERS, CONTINENTAL ARMY COMMAND, FORT MONROE, VIRGINIA; FROM 8-9 JANUARY 1960 AT THE QUARTERMASTER RESEARCH AND ENGINEERING CENTER, NATICK, MASSACHUSETTS; AND FROM 11-12 APRIL 1960 AT THE CHEMICAL CORPS PROVING GROUND, DUGWAY, UTAH. THIS ADVISORY SUBPANEL, WHICH REPORTS DIRECTLY TO THE SECRETARY OF THE ARMY, REVIEWS PLANS AND PROGRAMS WITHIN THE FIELDS OF GEOPHYSICAL SCIENCES AND HUMAN BIOLOGICAL SCIENCES AND RECOMMENDS WAYS OF IMPROVING RESEARCH AND THE APPROACHES TO RESEARCH FOR THE PURPOSE OF

IMPROVING ARMY CAPABILITIES FOR OPERATION UNDER ALL ENVIRONMENTAL CONDITIONS. REPORTS PREPARED AS A RESULT OF THESE MEETINGS ARE RESTRICTED TO STAFF DISTRIBUTION AND TO AGENCIES OTHER THAN STAFF INVOLVED IN THE COMMENTS.

THE ARMY COMMITTEE ON ENVIRONMENT HELD ITS 45TH MEETING IN WASHINGTON, D.C., ON 15 DECEMBER 1959. TOPICS COVERED INCLUDED A REPORT ON THE POLAR PROGRAM, PLANS FOR SPECIAL FIELD EXERCISE, ICE CAP, REPORTS ON GROUND MOBILITY AND VEHICLE MOBILITY PROGRAMS, ENVIRONMENTAL ACTIVITIES WITHIN THE TRANSPORTATION CORPS, ENVIRONMENTAL TESTING ACTIVITIES IN USCONARC, THE TECHNICAL SERVICES ENVANAL PROJECT IN THE ORDNANCE CORPS, PLANS FOR SIMULATED ENVIRONMENTAL TESTING IN THE CHEMICAL CORPS, TECHNICAL SERVICE PLANS FOR DESERT AND HOT-WEATHER RESEARCH AND TESTING AT YUMA TEST STATION, RECENT AND CURRENT ARMY SUPPORT OF SCIENTIFIC EXPEDITIONS, AND A REPORT ON ACTIVITIES WITHIN EACH OF THE TWO ACE PANELS.

WITH THE GROWING NEED FOR GREATER RELIABILITY IN THE PERFORMANCE OF MILITARY EQUIPMENT AND MATERIEL, THE TECHNICAL SERVICES OF THE ARMY HAVE BECOME INCREASINGLY AWARE OF THE NEED FOR CLOSER LIAISON AND COOPERATION IN THE EXCHANGE OF IDEAS AND DATA AS THEY APPLY TO THE DESIGN, DEVELOPMENT, AND TESTING OF MILITARY EQUIPMENT AND MATERIEL. DEFICIENCIES DUE TO LACK OF KNOWLEDGE OF PROJECTS UNDERWAY HAVE BEEN LARGELY OVERCOME. CURRENT DEFICIENCIES INCLUDE THE NEED FOR: RESEARCH ON ENVIRONMENTAL FACTORS CAUSING IMPAIRMENT IN PERFORMANCE OF MILITARY EQUIPMENT AND MATERIEL, PROVISIONS FOR ATTAINING MORE REALISTIC MEASUREMENTS OF ENVIRONMENTAL STRESSES, AND A WELL-BALANCED LONG-RANGE RESEARCH PROGRAM DEVELOPED IN CONSONANCE WITH ADVANCED PLANNING OBJECTIVES.

WITHIN THE DEPARTMENT OF THE ARMY, ONE MEANS OF IMPROVING LIAISON ACTIVITIES HAS BEEN THROUGH THE ARMY COMMITTEE ON ENVIRONMENT, PANEL ON ENVIRONMENTAL RESEARCH. SIX MEETINGS WERE HELD DURING THE YEAR THROUGHOUT THE UNITED STATES AND CANADA. OBSERVATIONS WERE MADE OF TESTING ACTIVITIES AT ABERDEEN PROVING GROUND IN JUNE, YUMA TEST STATION IN JULY, ARCTIC TEST BOARD AT FORT GREELY, ALASKA, IN JANUARY, AND AT A JOINT MEETING WITH THE PANEL ON ENVIRONMENTAL PHYSIOLOGY, ARMY COMMITTEE ON ENVIRONMENT, AT THE WATERWAYS EXPERIMENT STATION IN VICKSBURG IN MAY. A VERY FRUITFUL MEETING WAS HELD WITH THE CANADIAN DEFENSE RESEARCH BOARD IN OTTAWA, ONTARIO, IN OCTOBER FOR THE EXCHANGE OF ENVIRONMENTAL RESEARCH PROGRAM DATA, AND A BUSINESS MEETING WAS HELD IN WASHINGTON, D.C., IN MARCH. AS A RESULT OF EXPERIENCE GAINED THROUGH THESE MEETINGS, RECOMMENDATIONS FOR THE DISSEMINATION OF KNOWLEDGE, FOR EMPHASIZING THE NEED OF BASIC RESEARCH ON THE ENVIRONMENT, AND FOR LENDING SUPPORT TO EXISTING PROJECTS WERE REFERRED TO THE PARENT ARMY COMMITTEE ON ENVIRONMENT FOR ACTION.

USCONARC, AS A PRIMARY REPRESENTATIVE OF THE U.S. ARMY IN THE FIELD--THE USER--IS VITALLY CONCERNED WITH ALL FACETS OF ENVIRONMENTAL RESEARCH AND OPERATIONS. FORCES DEPLOYED OVERSEAS AND STRAC AND STRAF FORCES MUST

BE ABLE, WITH THE EQUIPMENT AUTHORIZED FOR AND AVAILABLE TO THEM, TO MOVE PROMPTLY, EFFECTIVELY, AND EFFICIENTLY AS EMERGENCIES ARISE ANYWHERE ON EARTH UNDER THE MOST SEVERE AND DIFFICULT ENVIRONMENTAL EXTREMES. THUS USCONARC IS IN POSITION TO PROVIDE THE LABORATORY SCIENTIST WITH A CLOSER CONTACT WITH REALITY THAN HE MIGHT ORDINARILY HAVE.

USCONARC MAY, THROUGH QUANTITATIVE MATERIAL DEVELOPMENT OBJECTIVES AND QMR'S, SUGGEST PROJECTS OR TASKS TO RESEARCH AGENCIES. THEY WILL NOT ORDINARILY TAKE PART IN THIS RESEARCH BEYOND PROVIDING SUCH MANPOWER OR MATERIEL SUPPORT AS MAY BE REQUIRED. USCONARC IS INTERESTED IN EXPLOITING THE RESULTS OF TECHNICAL SERVICES' RESEARCH TO DETERMINE THE LIMITATION AND CAPABILITIES OF MEN AND MATERIEL IN ENVIRONMENTAL EXTREMES, AND TO TRY TO REDUCE THESE LIMITATIONS OR EXPAND THESE CAPABILITIES. IN THE DEVELOPMENT OF MATERIEL, USCONARC MAINTAINS CLOSE LIAISON WITH DEVELOPING AGENCIES, PROVIDING GUIDANCE ON THE EQUIPMENT'S EXPECTED USE; AND WHEN THE EQUIPMENT IS FINALLY DEVELOPED, ACTIVE PARTICIPATION IN AN OPERATIONAL SENSE IS PROVIDED THROUGH SERVICE TESTING IN THE ARCTIC, DESERT, AND JUNGLE.

THE ARCTIC TEST BOARD, USCONARC'S ONLY FULL-TIME ENVIRONMENTAL TEST ACTIVITY, HAS 140 SCHEDULED TESTS IN THE CURRENT FISCAL YEAR. MOST OF THESE TESTS ARE WINTER TESTS, BUT A NUMBER OF TESTS, PARTICULARLY THOSE HAVING TO DO WITH TRAFFICABILITY, MUST BE CARRIED OUT ON A YEAR-ROUND BASIS.

THE DESERT PRESENTS MAJOR PROBLEMS DUE TO HIGH AMBIENT TEMPERATURES, SHORTAGE OF WATER, AND INCREASED MAINTENANCE AND REPLACEMENT OWING TO THE ABRASIVENESS OF SOIL PARTICLES. THIRTEEN ITEMS OF EQUIPMENT WERE SUMMER TESTED BY ARMOR AND AVIATION BOARD REPRESENTATIVES. TEST ITEMS INCLUDED: TRACK-LAYING VEHICLES, TANK AMMUNITION, M-1 CUPOLA SLIP RINGS FOR M-48 TANKS, MAINTENANCE FRAME COVERS FOR TRACK AND WHEEL VEHICLES, FUEL INJECTION DEVICES FOR LIGHT AIRCRAFT, A NEW GAS TURBINE HELICOPTER, AND AN ABSOLUTE ALTIMETER FOR AIRCRAFT.

AS FAR AS EQUIPMENT IS CONCERNED, USCONARC FEELS THAT ONE OF ITS MAIN PROBLEMS IS ASSOCIATED WITH HIGH TEMPERATURES AND HIGH HUMIDITY. SINCE THESE ELEMENTS OF THE ENVIRONMENT CAN BE REPRODUCED IN TEST CHAMBERS, A VERY SMALL AMOUNT OF FIELD TESTING IS CARRIED OUT BY USCONARC IN THE JUNGLE, AND THIS IS USUALLY CARRIED OUT BY THE JUNGLE WARFARE TRAINING CENTER.

## CHAPTER II: ACCOMPLISHMENTS OF THE TECHNICAL SERVICES

### 1. QUARTERMASTER CORPS

AS THE COGNIZANT TECHNICAL SERVICE WITHIN THE DEPARTMENT OF THE ARMY, THE QUARTERMASTER CORPS COORDINATES THE ARMY'S ENVIRONMENTAL RESEARCH AND DEVELOPMENT PROGRAM AND CONDUCTS MOST OF THE APPLIED ENVIRONMENTAL RESEARCH, IN THE STRICT SENSE, WITHIN THE ARMY. SEVERAL OF THE STUDIES REPORTED HEREIN ARE MENTIONED ONLY BRIEFLY BECAUSE THEY ARE CONTINUING, LONG-TERM PROJECTS THAT HAVE BEEN REPORTED PREVIOUSLY IN DETAIL; OTHERS ARE DISCUSSED IN DETAIL TO PROVIDE AN EXPLANATION OF THE RESEARCH UNDERTAKEN.

OVER THE YEARS, THE APPLIED ENVIRONMENTAL RESEARCH PROGRAM OF THE ARMY HAS COME TO FOLLOW THREE QUITE DISTINCT YET COORDINATED LINES OF ATTACK. THE FIRST TWO OF THESE ARE TRADITIONAL IN ALL GEOPHYSICAL SCIENCES AND ARE KNOWN AS "SYSTEMATIC" AND "REGIONAL."

THE SYSTEMATIC APPROACH SEEKS TO DISCOVER RELATIONSHIPS BETWEEN EASY-TO-OBTAIN ENVIRONMENTAL DATA AND DATA NEEDED BY THE ARMY. FROM SUCH KNOWLEDGE, METHODS ARE DEVELOPED FOR PREDICTING WITH GREATER QUANTITATIVE ACCURACY THE NATURE OF THE ENVIRONMENT TO BE EXPECTED IN ANY GIVEN PLACE AT ANY TIME OF THE YEAR. THIS LINE OF ATTACK IS USUALLY SUCCESSFUL IN PARTS OF THE WORLD FOR WHICH AT LEAST A MODERATE AMOUNT OF DATA ARE AVAILABLE.

THE REGIONAL APPROACH IS ESPECIALLY APPLICABLE TO PARTS OF THE WORLD FOR WHICH LITTLE DATA ARE AVAILABLE. AS WOULD BE EXPECTED, SUCH AREAS ARE USUALLY IN THE MORE REMOTE PARTS OF POLAR, MOUNTAIN, TROPIC, AND DESERT AREAS. TO UNDERSTAND SUCH AREAS IT IS OFTEN NECESSARY TO GO INTO THE FIELD AND STUDY THE ENVIRONMENT FIRSTHAND. THERE IS, HOWEVER, NO HARD AND FAST SET OF CRITERIA WHICH SEPERATES AREAS INTO TYPES MOST AMENABLE TO EITHER THE SYSTEMATIC OR REGIONAL APPROACH, AND KNOWLEDGE OF ANY AREA CAN BE IMPROVED BY THE USE OF BOTH APPROACHES.

THE THIRD APPROACH USES ENVIRONMENTAL INFORMATION FROM EVERY SOURCE POSSIBLE AND INTRODUCES THE ENVIRONMENTAL CAPABILITIES OF ARMY EQUIPMENT NOW AVAILABLE OR REQUIRED IN THE FUTURE. THE MATCHING OF THESE TWO TYPES OF DATA ALONG WITH CONSIDERATIONS OF CALCULATED RISK AND RELATIVE COST RESULTS IN DOCUMENTS WHICH EITHER STRONGLY ADVISE OR, WHEN GIVEN OFFICIAL APPROVAL, REQUIRE COMPLIANCE. SUCH PUBLICATIONS MAY DEAL WITH ENVIRONMENTAL DESIGN AND TEST STANDARDS OR CONTAIN REQUIREMENTS FOR THE SEASONAL ISSUE OF SPECIFIED KINDS OF EQUIPMENT IN VARIOUS PARTS OF THE WORLD. INSTANCES OF ENVIRONMENTALLY INDUCED EQUIPMENT FAILURE IN THE FIELD OR IN STORAGE PROVIDE A FEED-BACK OF INFORMATION TO THOSE DOING RESEARCH ON THE ENVIRONMENT.

## A. PREDICTIVE METHODS

### (1) TEMPERATURE FREQUENCY PREDICTION

THE ONLY AVAILABLE TEMPERATURE DATA FOR MOST WEATHER STATIONS ARE MONTHLY MEANS AND EXTREMES. EVEN WHEN CONSIDERED TOGETHER, THIS INFORMATION TELLS LITTLE ABOUT THE PERCENT OF TIME GIVEN TEMPERATURE VALUES LYING BETWEEN THE EXTREMES MAY BE EXPECTED. SUCH INFORMATION IS NEEDED IN ESTABLISHING DESIGN CRITERIA AND IN THE ISSUE OF EQUIPMENT.

A RECENTLY DEVELOPED METHOD SHOWS THAT IF THE MEAN MONTHLY TEMPERATURE AND THE EXTREMES FOR A PLACE ARE KNOWN, THEN THE HOURLY FREQUENCIES OF TEMPERATURE MAY BE PREDICTED WITH CONSIDERABLE CONFIDENCE BY MEANS OF A NOMOGRAPH (FIG. 1). THE METHOD IS EASILY ADAPTABLE TO MACHINE PROCESSING AND TABULATION. THE PREDICTIVE CAPABILITIES OF THE METHOD ARE BEING USED FOR THE DEGREE-QUADRANGLE COLLATION OF ENVIRONMENTAL DATA. TEMPERATURE DATA FROM GREENLAND AND THE COUNTRIES OF SOUTHWEST ASIA ALREADY HAVE BEEN PROCESSED.

A COMPANION STUDY DEALS WITH THE DAILY MINIMUM TEMPERATURES THAT MAY BE EXPECTED. IN THIS CASE THE NOMOGRAPH AND MACHINE PROCESSING UTILIZE THE EXTREME TEMPERATURES FOR THE MONTH AND THE MEAN DAILY MINIMUM.

THE METHODS USED IN THESE STUDIES ARE SUCH THAT EACH FURNISHES A TABLE OF CONSTANT VALUES WHICH MAKES PROCESSING BY EAM MACHINES A COMPARATIVELY SIMPLE MATTER.

FREQUENCIES OF TEMPERATURE GENERATED BY THESE METHODS COME CLOSER TO DUPLICATING THE LONG-TERM TEMPERATURE FREQUENCIES RECORD OF A STATION THAN DOES A STATISTICAL DISTRIBUTION OF TEMPERATURES COLLECTED OVER A SINGLE YEAR'S TIME.

### (2) WINDCHILL FREQUENCY PREDICTION

THE WINDCHILL FREQUENCY PREDICTION METHOD, USING ONLY MEAN MONTHLY TEMPERATURE AND WIND SPEED (AS REPORTED IN THE JUNE 1958 ANNUAL REPORT) HAS BEEN IMPROVED AND EXTENDED TO THE 2000 WINDCHILL INDEX, AND FURTHER TESTING HAS BEEN ACCOMPLISHED. THE METHOD HAS ALSO BEEN ADAPTED FOR USE WITH EAM MACHINES. THE RESULTS OF AN EXTENSIVE TEST OF THE METHOD SHOW THAT PREDICTION OF THE EXPECTED WINDCHILL LEVEL FOR A GIVEN PERCENT OF THE TIME HAS ERRORS WHICH RANGE BETWEEN 0 AND 240 WINDCHILL UNITS WITH A MEAN OF 52. MOST OF THE LARGE ERRORS OCCUR IN PREDICTIONS OF WINDCHILL LEVELS GREATER THAN WOULD NORMALLY BE EXPECTED AT THE LOW END OF THE SCALE.

### (3) SOLAR RADIATION STUDIES

OBSERVATIONS OF SOLAR RADIANT ENERGY RECEIVED AT THE SURFACE OF THE EARTH HAVE BEEN MADE IN MOST PARTS OF THE WORLD FOR ONLY A BRIEF

# HOURLY TEMPERATURE NOMOGRAPH

## SECTION "A"

Seoul, Korea: July Temperature

Essential Data	Converted, Hourly Temperature Probability	Reconverted, Hourly Temperature Probability
Actual Reduced	1%	0%
97°-Mi	100°-Cm	100°-Cm
77°-Mi	100°-Cm	100°-Cm
57°-Mi	100°-Cm	100°-Cm
37°-Mi	100°-Cm	100°-Cm
17°-Mi	100°-Cm	100°-Cm
0°-Mi	100°-Cm	100°-Cm
-20°-Mi	100°-Cm	100°-Cm
-40°-Mi	100°-Cm	100°-Cm
-60°-Mi	100°-Cm	100°-Cm
-80°-Mi	100°-Cm	100°-Cm
-100°-Mi	100°-Cm	100°-Cm
-120°-Mi	100°-Cm	100°-Cm
-140°-Mi	100°-Cm	100°-Cm
-160°-Mi	100°-Cm	100°-Cm
-180°-Mi	100°-Cm	100°-Cm
-200°-Mi	100°-Cm	100°-Cm
-220°-Mi	100°-Cm	100°-Cm
-240°-Mi	100°-Cm	100°-Cm
-260°-Mi	100°-Cm	100°-Cm
-280°-Mi	100°-Cm	100°-Cm
-300°-Mi	100°-Cm	100°-Cm
-320°-Mi	100°-Cm	100°-Cm
-340°-Mi	100°-Cm	100°-Cm
-360°-Mi	100°-Cm	100°-Cm
-380°-Mi	100°-Cm	100°-Cm
-400°-Mi	100°-Cm	100°-Cm
-420°-Mi	100°-Cm	100°-Cm
-440°-Mi	100°-Cm	100°-Cm
-460°-Mi	100°-Cm	100°-Cm
-480°-Mi	100°-Cm	100°-Cm
-500°-Mi	100°-Cm	100°-Cm
-520°-Mi	100°-Cm	100°-Cm
-540°-Mi	100°-Cm	100°-Cm
-560°-Mi	100°-Cm	100°-Cm
-580°-Mi	100°-Cm	100°-Cm
-600°-Mi	100°-Cm	100°-Cm
-620°-Mi	100°-Cm	100°-Cm
-640°-Mi	100°-Cm	100°-Cm
-660°-Mi	100°-Cm	100°-Cm
-680°-Mi	100°-Cm	100°-Cm
-700°-Mi	100°-Cm	100°-Cm
-720°-Mi	100°-Cm	100°-Cm
-740°-Mi	100°-Cm	100°-Cm
-760°-Mi	100°-Cm	100°-Cm
-780°-Mi	100°-Cm	100°-Cm
-800°-Mi	100°-Cm	100°-Cm
-820°-Mi	100°-Cm	100°-Cm
-840°-Mi	100°-Cm	100°-Cm
-860°-Mi	100°-Cm	100°-Cm
-880°-Mi	100°-Cm	100°-Cm
-900°-Mi	100°-Cm	100°-Cm
-920°-Mi	100°-Cm	100°-Cm
-940°-Mi	100°-Cm	100°-Cm
-960°-Mi	100°-Cm	100°-Cm
-980°-Mi	100°-Cm	100°-Cm
-1000°-Mi	100°-Cm	100°-Cm

## SECTION "B"

Conversion Formula:

$$Cm = \frac{100 (Mn - Mi)}{Mx - Mi}$$

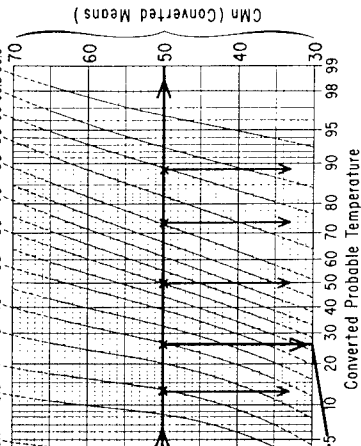
Example:  $Cm = \frac{100 (77 - 57)}{97 - 57} = 50$

Percentage Relations

between

Converted Means and Converted Probable Temperatures

0.1 0.5 1 5 10 30 50 70 90 95 99 99.5 99.9



Re-conversion Formula:

$$PT (Fahr) = CT \left( \frac{Mx - Mi}{100} \right) + Mi$$

Example:

10% PT (Fahr) =  $26 \left( \frac{97 - 57}{100} \right) + 57 = 67^\circ$

FIGURE 1. NOMOGRAPH FOR ASSESSING HOURLY TEMPERATURE PROBABILITIES FOR A GIVEN MONTH WHEN ONLY THE MEAN, THE EXTREME MINIMUM, AND EXTREME MAXIMUM ARE AVAILABLE. THE 41 PATTERNS OF ASYMMETRY (30 TO 70, INCLUSIVE), SHOWN IN SECTION "B," COVER THE WIDE RANGE OF HOURLY TEMPERATURE DISTRIBUTION TO BE EXPECTED ANYWHERE FROM POLAR TO TROPICAL AREAS.

PERIOD OF YEARS. A STUDY WAS INITIATED TO EVALUATE THESE SHORT RECORDS, AND THE FEW LONG RECORDS AVAILABLE, FOR APPLICATION TO THE ESTABLISHMENT OF DESIGN CRITERIA. AS A POINT OF REFERENCE, THE 25-30 YEAR RECORDS (THE LONGEST AVAILABLE) FOR BLUE HILL OBSERVATORY, MASSACHUSETTS; LINCOLN, NEBRASKA; AND FRESNO, CALIFORNIA, WERE USED TO DETERMINE THE STABILITY OF SOLAR RADIATION OVER A PERIOD OF YEARS. RESULTS INDICATE THAT MEASURES OF CENTRAL TENDENCY ARE SUBJECT TO BOTH YEAR-TO-YEAR VARIATIONS AND CYCLIC TRENDS EXTENDING OVER SEVERAL YEARS. THE LARGE MAGNITUDE OF THE LATTER APPEARS TO PRECLUDE THE USE OF SHORT RECORDS FOR ESTABLISHMENT OF PRECISE DESIGN CRITERIA. IT MAY BE POSSIBLE TO SOLVE THIS SHORT-RECORD PROBLEM BY USING THE STRONG CORRELATION KNOWN TO EXIST BETWEEN CLOUD COVER AND RADIATION. STATIONS WITH SHORT RADIATION RECORDS AND LONG CLOUD-COVER RECORDS COULD BE USED TO CONSTRUCT THE LONG-RANGE RADIATION TREND OF THE AREA. MEAN DAILY CLOUD COVER DATA FOR 30 YEARS OF RECORD AT LINCOLN AND FRESNO WERE OBTAINED FROM THE NATIONAL WEATHER RECORDS CENTER TO PERMIT THE TESTING OF THIS HYPOTHESIS.

THE AMOUNT OF SOLAR RADIANT ENERGY RECEIVED IN AN HOUR IS MORE VALUABLE THAN THAT RECEIVED IN A DAY IN THE SOLUTION OF MANY EQUIPMENT DESIGN AND PHYSIOLOGICAL PROBLEMS, BUT HOURLY DATA ARE SCARCE RELATIVE TO DAILY DATA. TO OVERCOME THIS DIFFICULTY, WORK WAS STARTED TO DEVELOP A METHOD TO PREDICT HOURLY RADIATION VALUES FROM DAILY TOTALS. A SIMPLE TECHNIQUE, EMPLOYING THE KNOWN HOURLY AND DAILY VALUES RECEIVED AT THE TOP OF THE ATMOSPHERE, WAS DEVISED AND TESTED AGAINST 3 YEARS OF DATA COLLECTED AT NATICK, MASS. CORRELATIONS BETWEEN PREDICTED AND ACTUAL HOURLY RADIATION ARE HIGH FOR THE DATA TESTED TO DATE (0.962 FOR MARCH-MAY AND 0.947 FOR JUNE-AUGUST). THE STANDARD ERROR OF ESTIMATE FOR HOURLY VALUES FOR THE TWO PERIODS ARE 6.1 AND 7.7 LANGLEYS, RESPECTIVELY. A METHOD FOR PREDICTING THE FREQUENCIES OF HOURLY RADIATION BY 10-LANGLEY CLASS INTERVALS, IN WHICH A CORRECTION FOR LINEAR REGRESSION ERROR FROM THE CONDITION  $X = Y$  IS APPLIED, WAS DEVELOPED AND TESTED AGAINST THE NATICK DATA, AND GIVES PROMISE OF PROVIDING REASONABLE ACCURACY (FIG. 2).

OBSERVATIONS OF SOLAR AND TERRESTRIAL RADIANT ENERGY CONTINUED AT NATICK, MASS., FOR THE FOURTH YEAR. THE COMPONENTS MEASURED INCLUDE INCOMING LONG-WAVE AND SHORT-WAVE SOLAR AND SKY RADIATION AND THE BALANCE OF INCOMING AND OUTGOING RADIATION OF ALL WAVE LENGTHS AT THE SURFACE OF THE GROUND. SIMILAR MEASUREMENTS WERE MADE FOR THE QUARTERMASTER CORPS BY THE SIGNAL CORPS METEOROLOGY DEPARTMENT AT YUMA TEST STATION AND FORT HUACHUCA, ARIZONA, AND AT FORT CLAYTON, CANAL ZONE. THE YUMA DATA HAVE BEEN PLACED ON IBM PUNCH CARDS AND THE 8-YEAR RECORD FOR THAT STATION CURRENTLY IS BEING ANALYZED BY MACHINE METHODS. NEGOTIATIONS WERE CONDUCTED WITH THE SIGNAL CORPS METEOROLOGY DEPARTMENT TO OBTAIN AN INSTRUMENT TO MEASURE SOLAR RADIATION IN SEVERAL PRECISE BANDS OF THE SOLAR SPECTRUM. THIS EQUIPMENT WILL BE USED TO SUPPORT STUDIES OF THE PHOTO-OXIDATIVE DETERIORATION OF FABRICS AND OTHER MATERIALS.

# FREQUENCY OF HOURLY SOLAR RADIATION VALUES

NATICK, MASS.

March, April, May  
1957, 1958, 1959

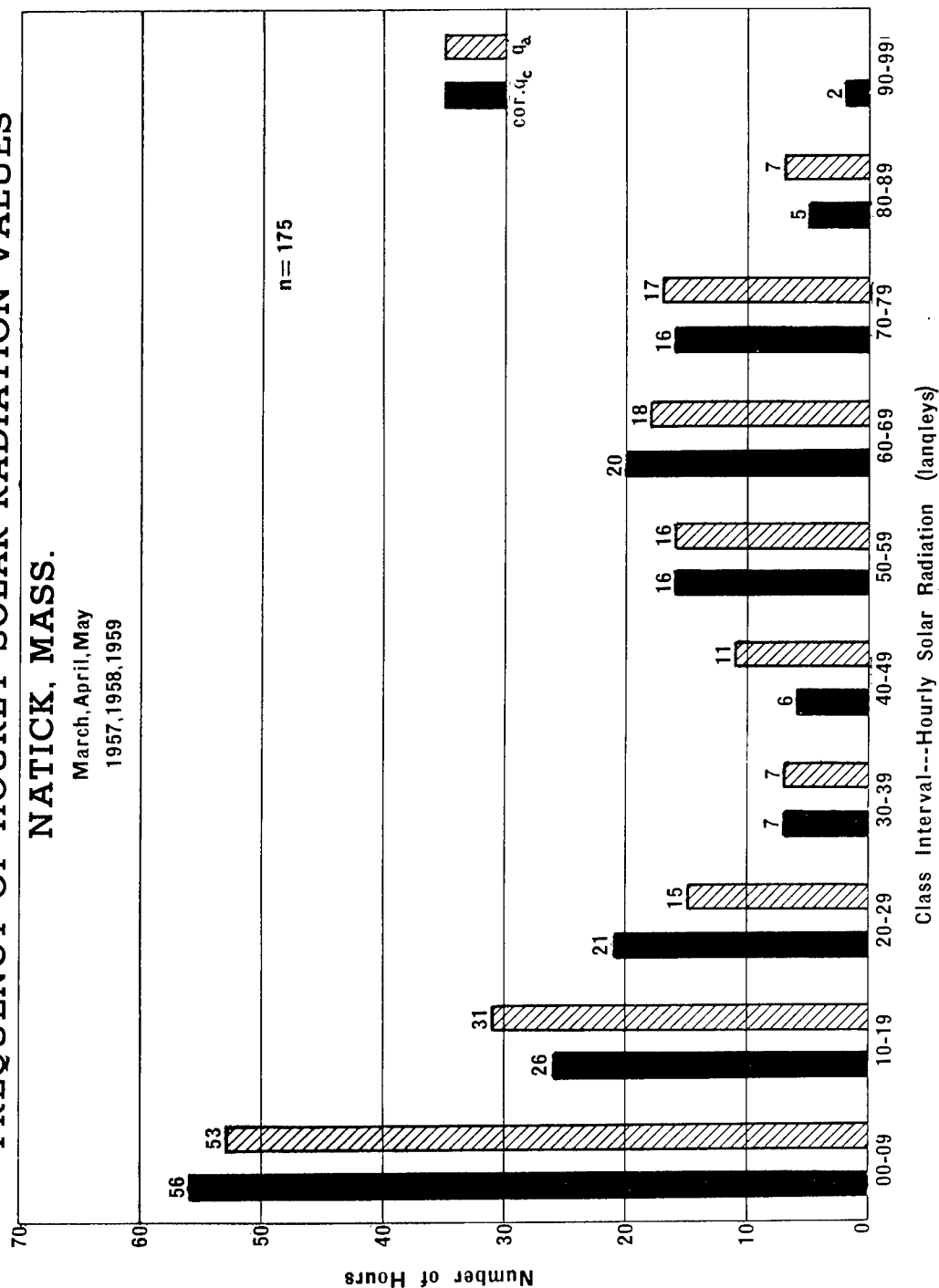


FIGURE 2. THE SOLID BLACK BARS REPRESENT THE PREDICTED FREQUENCIES FOR EACH CLASS INTERVAL OF RADIATION, AND THE HATCHED BARS THE ACTUAL FREQUENCIES. THE METHOD IS BASED ON THE FACT THAT  $Q_A \approx Q_C$ , AND  $Q_C = (Q_A/Q_0)Q_0$  ( $Q_0$  AND  $Q_C$  REPRESENT THE DAILY AND HOURLY RADIATION RECEIVED AT THE OUTER LIMITS OF THE ATMOSPHERE;  $Q_A$  AND  $Q_C$  THE DAILY AND HOURLY RADIATION ACTUALLY RECEIVED AT THE SURFACE OF THE EARTH). THE VALUE  $Q_C$  IS  $Q_C$  CORRECTED FOR REGRESSION ERROR TO THE CONDITION  $Q_C = Q_A$ .



#### (4) QUANTITATIVE TERRAIN ANALYSIS

ONE OF THE GAPS IN KNOWLEDGE OF THE ENVIRONMENT HAS BEEN THE LACK OF CONTROLLED GENERALIZED INFORMATION ABOUT EARTH CONFIGURATION; THERE ARE LARGE-SCALE, DETAILED TOPOGRAPHIC MAPS AND SMALL-SCALE, HYPSO-METRIC MAPS, BUT NOTHING IN BETWEEN.

THEREFORE, A LANDFORM CLASSIFICATION SYSTEM (22), BASED ON QUANTITATIVE TERRAIN DATA, HAS BEEN DEVISED AND TESTED IN A PART OF CENTRAL EUROPE. MEASUREMENTS FOR SIX TERRAIN FACTORS - GRAIN, RELIEF, AVERAGE ELEVATION, ELEVATION-RELIEF RATIO, AVERAGE SLOPE, AND SLOPE DIRECTION CHANGES - WERE TAKEN FOR 413 SAMPLE AREAS WITHIN A LARGER AREA OF OVER 100,000 SQUARE MILES. THE INDIVIDUAL SAMPLES WERE GROUPED INTO 25 HOMOGENEOUS REGIONS IN ACCORDANCE WITH THE SIMILARITY OF THE ABOVE MEASUREMENTS.

A MAP OF CENTRAL EUROPE DELINEATING THESE 25 REGIONS WAS DRAWN AND WAS FOUND TO COMPARE FAVORABLY WITH PHYSIOGRAPHIC MAPS OF THE SAME AREA DRAWN SOLELY FROM QUALITATIVE INTERPRETATIONS. THE SIMILARITY OF THE QUANTITATIVELY-DESCRIBED LANDFORM REGIONS WITH THOSE DESCRIBED QUALITATIVELY IS PROOF OF THE VALIDITY OF QUANTITATIVE TERRAIN ANALYSIS AND DEMONSTRATES THE USEFULNESS OF EARLIER QUALITATIVE GEOGRAPHIC WORK.

INFORMATION OF THIS TYPE THUS FILLS A NEED IN TERRAIN STUDIES SIMILAR TO THAT WHICH WAS MET LONG AGO IN CLIMATOLOGY BY THE DEVELOPMENT OF SUCH MEASURES AS MEAN DAILY MINIMUM TEMPERATURE, AVERAGE GROWING SEASON, AND MEAN MONTHLY RAINFALL.

ALSO, A TECHNIQUE HAS BEEN DEVELOPED (32) BY WHICH TOPOGRAPHIC RELIEF REPRESENTATIVE OF THE VICINITY OF ANY GIVEN POINT CAN BE OBJECTIVELY MEASURED. BY MEANS OF A NOMOGRAPH, LARGE IMAGINARY SPHEROIDS ARE BROUGHT INTO "CONTACT" WITH THE EARTH'S SURFACE FROM ABOVE AND BELOW IN SUCH A WAY AS TO SERVE AS "INSTRUMENTS" TO MEASURE THE ROUGHNESS OF TOPOGRAPHY. VALLEY WIDTHS REPRESENTATIVE OF THE SAME VICINITY CAN BE ESTIMATED OBJECTIVELY BY MEANS OF FURTHER STEPS IN THE PROCEDURE. DATA USED IS FROM TOPOGRAPHIC MAPS.

A METHOD FOR PREDICTING LINE-OF-SIGHT INFORMATION THROUGH THE USE OF A MATHEMATICAL MODEL HAS BEEN DEVELOPED (21). DIMENSIONS OF RELIEF, AVERAGE SLOPE, VALLEY SPACING, AND DISTANCE BETWEEN TWO POINTS ON THE EARTH'S SURFACE AS MEASURED ON A MAP WERE PUT THROUGH A SERIES OF COMPUTATIONS WHICH RESULTED IN DIMENSIONS OF VALLEY SPACING, RIDGE-VALLEY DISTANCE, VALLEY DEPTH, ANGLE OF SIGHT, RIDGE-INTERFERENCE DISTANCE, AND ANGLE OF VALLEY ENTRANCE IN A SIMPLIFIED TERRAIN MODEL. THE ANGLE MADE BY VALLEY INTERSECTIONS WITH LINES OF SIGHT WAS FOUND TO BE CONVERTIBLE TO A PREDICTED NUMBER OF VALLEYS VISIBLE FROM A POINT AS FAR DISTANT AS 20 MILES. THE MODEL HAS BEEN TESTED ON 2 AREAS OF WIDELY CONTRASTING TERRAIN TYPES AND THE PREDICTED NUMBER OF VISIBLE VALLEYS IN BOTH CASES COMPARED FAVORABLY WITH THE NUMBER OF VALLEYS THAT ARE ACTUALLY VISIBLE FROM A POINT. A

COMPARISON OF THE ACTUAL NUMBER OF VALLEY BOTTOMS INVISIBLE FROM A POINT WITH THE NUMBER PREDICTED AS INVISIBLE IS SHOWN IN FIGURE 3. WORK IS CONTINUING WITH AN INVESTIGATION OF THE EFFECT OF VEGETATION ON LINES-OF-SIGHT. LINE-OF-SIGHT STUDIES HAVE A CLOSE CONNECTION TO THE PROBLEM OF VULNERABILITY OF LOW-FLYING AIRCRAFT AND ARE BEING CONDUCTED FOR THAT PURPOSE, BUT THERE ARE STRONG IMPLICATIONS IN THEM FOR OTHER MILITARY PROBLEMS AS WELL.

## B. REGIONAL RESEARCH

### (1) MICROCLIMATIC STUDIES

THE OBSERVATION AND ANALYSIS OF MICROCLIMATIC DATA FROM SELECTED ENVIRONMENTS WAS CONTINUED DURING THE PAST YEAR. ONE PURPOSE OF THE PROGRAM IS TO OBTAIN A MORE DETAILED UNDERSTANDING OF THE NATURAL ENVIRONMENT OF THE SOLDIER AND HIS EQUIPMENT THAN IS AVAILABLE FROM STANDARD OBSERVATIONS. A SECOND GOAL IS TO RELATE THESE MICROCLIMATIC DATA TO STANDARD WEATHER OBSERVATIONS, WHICH ARE MORE GENERALLY AVAILABLE, IN ORDER THAT THE RELATIONSHIPS BETWEEN MICROCLIMATE AND STANDARD "MACROCLIMATE" MAY BE BETTER UNDERSTOOD AND PREDICTED.

THE SIGNAL CORPS HAS COMPLETED OBSERVATION PROGRAMS AT YUMA TEST STATION, ARIZONA; FORT GREELY, ALASKA; THE CANAL ZONE; MOUNT WASHINGTON, NEW HAMPSHIRE; AND FORT BENNING, GEORGIA. A TECHNICAL REPORT DEALING WITH SUBARCTIC CONDITIONS HAS BEEN PUBLISHED (5) AND ANALYSIS OF THE YUMA MICROCLIMATIC DATA HAS BEEN COMPLETED AND PUBLISHED (7). NORMAL AFTERNOON AND NIGHTTIME VERTICAL TEMPERATURE PROFILES OVER THREE TYPES OF DESERT SURFACE AT YUMA ARE NOW KNOWN. DEVELOPMENT OF AN EXPRESSION OF THE SUMMER RELATIONSHIP BETWEEN THE SURFACE AND TWO-METER TEMPERATURE AT MID-DAY HAS MADE POSSIBLE THE ESTIMATION OF MAXIMUM SURFACE TEMPERATURES ON CLEAR DAYS FROM STANDARD TEMPERATURE DATA. ANALYSIS OF MICROCLIMATIC OBSERVATIONS IN THE CANAL ZONE ARE IN PROGRESS; ALTHOUGH TROPICAL AREAS ARE KNOWN FOR THEIR CLIMATIC UNIFORMITY, SUBSTANTIAL DIFFERENCES WERE FOUND AMONG VARIOUS TYPES OF SITES ON BOTH SIDES OF THE CANAL ZONE.

THE EXTENSIVE MICROMETEOROLOGICAL DATA COLLECTED BY A QMC SCIENTIST AT LITTLE AMERICA AND THE SOUTH POLE AS PART OF THE IGY PROGRAM IN ANTARCTICA ARE BEING REDUCED AND ANALYZED UNDER A TWO-YEAR GRANT FROM THE NATIONAL SCIENCE FOUNDATION. HALF THE DATA HAS BEEN PREPARED FOR MACHINE COMPUTATION; PRELIMINARY RESULTS WILL BE PRESENTED AT SCIENTIFIC MEETINGS TO BE HELD IN STOCKHOLM AND HELSINKI DURING THE SUMMER OF 1960.

A STUDY HAS BEEN MADE OF THE TEMPERATURE DIFFERENCES WITHIN THE STATION NETWORK ESTABLISHED ON THE GROUND OF THE QMR&E CENTER. THE PURPOSE OF THIS STUDY IS TO EVALUATE THE REPRESENTATIVENESS OF DATA FROM A SINGLE STATION WHEN COMPARED WITH OTHER DATA FROM THE SAME HOMOGENEOUS AREA.

# COMPARISON of PREDICTED and ACTUAL NUMBER of PROTECTED VALLEYS

GLENS FALLS SHEET AMS. 1:250,000

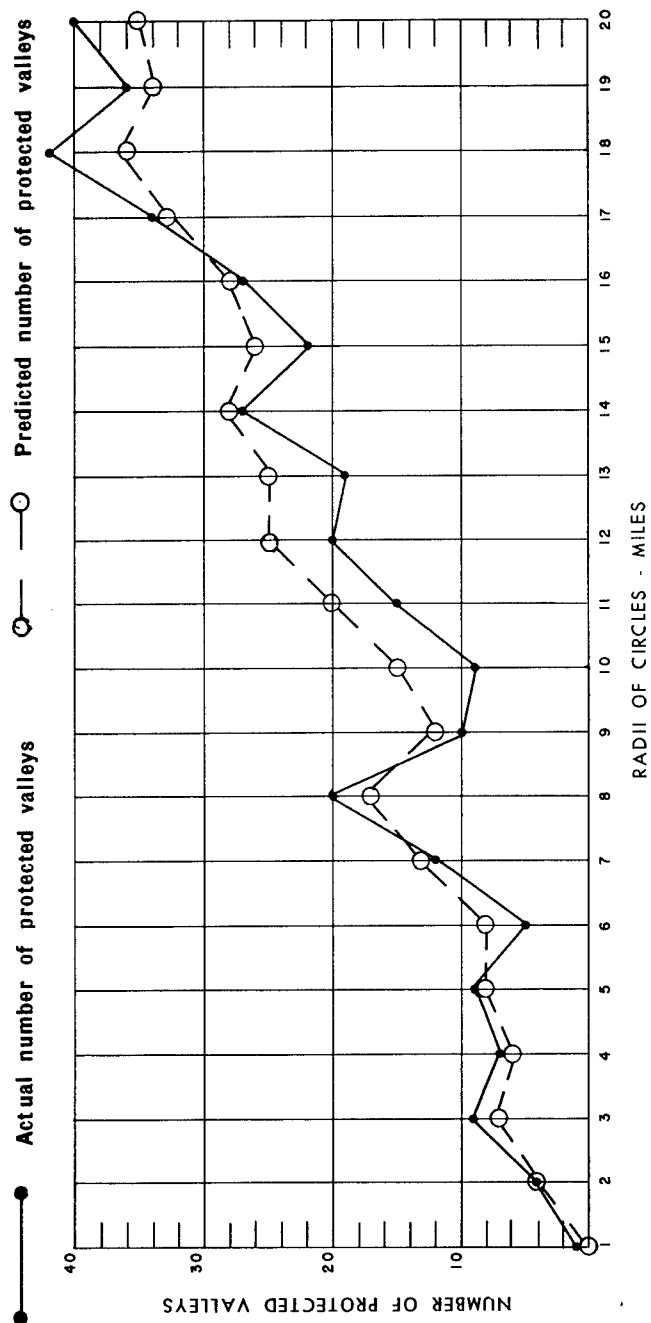


FIGURE 3. THE BLACK LINE REPRESENTS THE ACTUAL NUMBER OF PROTECTED VALLEYS AT INDICATED DISTANCES FROM THE VIEWING POINT AND WAS DETERMINED BY EXAMINING NEARLY 500 LINES OF SIGHT ON A TOPOGRAPHIC MAP. THE DASHED LINE IS CONSTRUCTED THROUGH THE USE OF A MATHEMATICAL MODEL AND USES EASILY OBTAINABLE MAP DATA. IT IS BETTER THAN 92% ACCURATE AND THE DATA NEEDED TO DRAW IT MAY BE OBTAINED IN A SMALL FRACTION OF THE TIME NEEDED TO CONSTRUCT THE SOLID LINE.

## (2) WORLD ANALOGS OF ARMY TEST SITES

THE COMPARISON OF WORLD ENVIRONMENTS WITH THOSE OF THE ARMY'S MAJOR TESTING SITES CONTINUED DURING THE YEAR. THE CORPS OF ENGINEERS, WITH OVERALL RESPONSIBILITY UNDER ITS PROJECT, "MILITARY EVALUATION OF GEOGRAPHIC AREAS," IS PREPARING TERRAIN ANALOGS; THE QUARTERMASTER CORPS, AT THE REQUEST OF THE CORPS OF ENGINEERS, IS PREPARING CLIMATIC ANALOGS.

DURING THE YEAR THE QMC PUBLISHED 2 CLIMATIC ANALOG STUDIES COMPARING TROPICAL CLIMATIC CONDITIONS IN INDONESIA, THE PHILIPPINES, AND BORNEO (17), AND AUSTRALIA AND NEW GUINEA (2) WITH THOSE IN THE PANAMA CANAL ZONE. TWO ADDITIONAL STUDIES, THE FAR EAST AND THE PACIFIC ISLANDS, ARE IN PRESS, THUS COMPLETING THE TROPICAL SERIES. THREE DESERT ANALOG STUDIES FOR THE SOUTHERN HEMISPHERE ARE NOW IN PREPARATION. PUBLICATION OF THESE DESERT STUDIES WILL COMPLETE THE CLIMATIC ANALOG PROGRAM. UPON TERMINATION OF THE STUDY A TOTAL OF 23 ANALOGS WILL BE AVAILABLE (10 TROPIC, 2 ARCTIC, 11 DESERT) FOR USE BY STAFF PERSONNEL IN DETERMINING LOGISTIC REQUIREMENTS FOR THE AREAS DESCRIBED.

## (3) GREENLAND STUDIES

STUDIES OF ENVIRONMENTAL CONDITIONS THAT WOULD AFFECT MILITARY ACTIVITIES IN VARIOUS SECTIONS OF GREENLAND ARE CONTINUING. A REPORT ON THE ENVIRONMENT OF SOUTHEAST GREENLAND WAS COMPLETED AND A SIMILAR STUDY OF THE ICECAP IS BEING PREPARED FOR PUBLICATION. THE SOUTHEAST AREA HAS THE SMALLEST AMOUNT OF GLACIER-FREE LAND SURFACE AND IS THE WARMEST, STORMIEST, AND MOST MOUNTAINOUS OF THE FOUR COASTAL REGIONS. ON THE ICECAP THERE ARE CONSIDERABLE CLIMATIC CONTRASTS (E.G., TEMPERATURE, WIND, AND VISIBILITY) BETWEEN THE INTERIOR AND COASTAL AREAS DURING ALL SEASONS. DRASTIC CHANGES IN WEATHER ALSO OCCUR FREQUENTLY ANYWHERE ON THE ICECAP. A COMPARABLE REPORT ON SOUTHWEST GREENLAND IS ALSO IN PROGRESS.

## (4) SMALL PARTY OPERATIONS

A SERIES OF FIELD STUDIES WAS CONDUCTED DURING 1959 ON ENVIRONMENTAL CONDITIONS THAT AFFECT SMALL-PARTY OPERATIONS IN POLAR REGIONS. IN CONNECTION WITH THIS PROGRAM, METEOROLOGICAL SUPPORT WAS PROVIDED TO QM POLAR PROJECT 59-1, "STUDY OF SMALL PARTY OPERATIONS ON THE GREENLAND ICECAP." OBSERVATIONS WERE MADE TO DETERMINE THE LOCAL CLIMATIC CONDITIONS IN THE VICINITY OF CAMP FISTCLENCH ON THE ICECAP (FIG. 4) FROM MID-JULY TO EARLY SEPTEMBER; RESULTS OF THE STUDY ARE SUMMARIZED IN A PUBLISHED REPORT (9).

QMC SCIENTISTS CONDUCTED METEOROLOGICAL, MICROMETEOROLOGICAL, AND ENVIRONMENTAL STUDIES DURING THE AFCRC-USAF-ARCTIC INSTITUTE OF NORTH AMERICA-USGS SPONSORED EXPEDITIONS TO LAKE PETERS, BROOKS RANGE, ALASKA, AND THE ARCTIC ICE SHELF, NEAR WARD HUNT ISLAND NORTH OF ELLESMERE ISLAND.

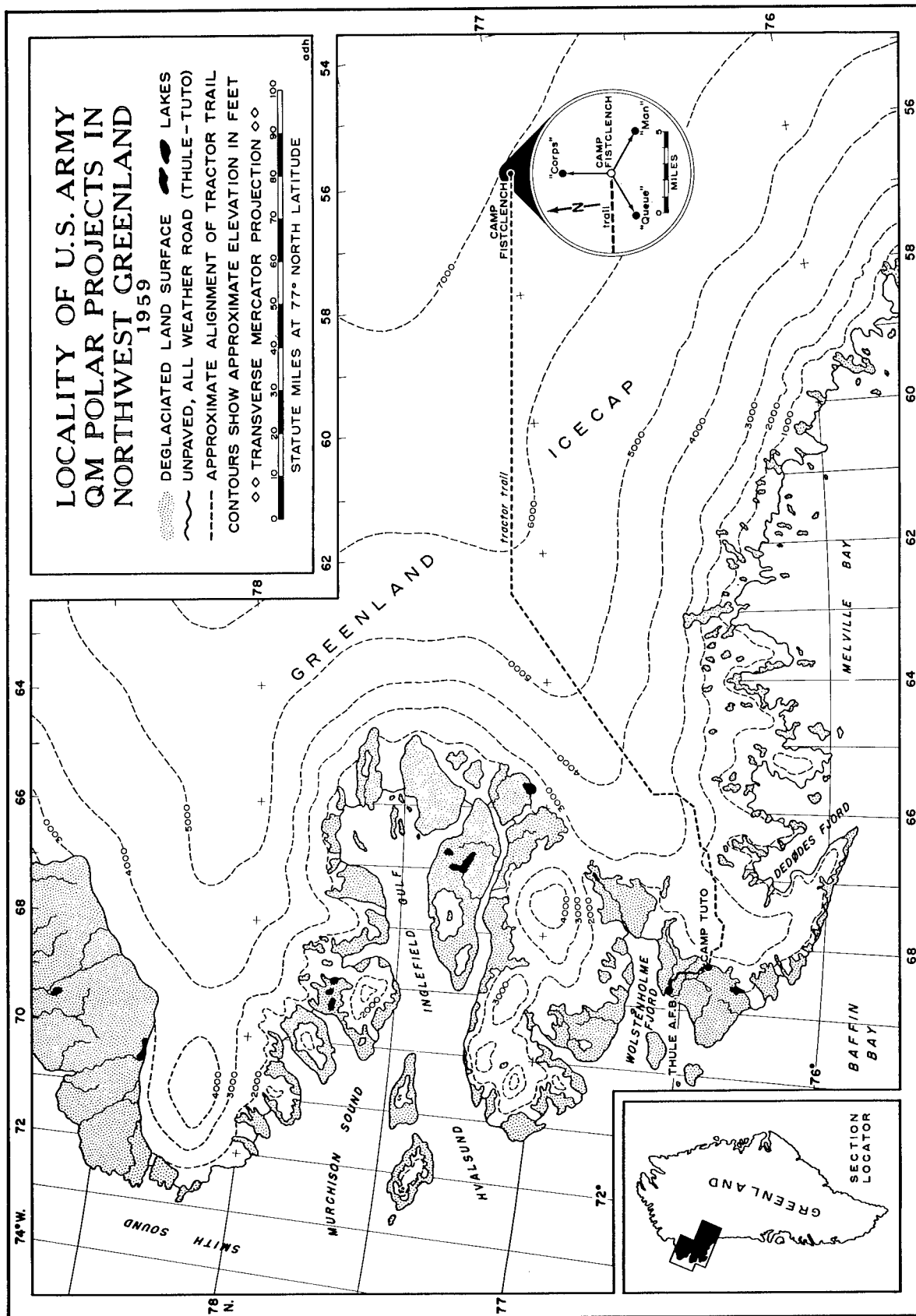


FIGURE 4

THE LAKE PETERS METEOROLOGICAL PROGRAM CONDUCTED DURING THE SUMMER OF 1959 WAS A CONTINUATION OF ONE ORIGINALLY INITIATED BY USGS, USAF, AND QMC PERSONNEL IN 1958. DATA COLLECTED PROVIDE INFORMATION ON AREAS FOR WHICH ADEQUATE RECORDS HAVE NOT BEEN AVAILABLE; THESE ARE NEEDED FOR USE IN PREPARATION OF AN ENVIRONMENTAL ATLAS, AND FOR PROPER EVALUATION OF PROBLEMS CONCERNED WITH MILITARY OPERATIONS IN THE ARCTIC.

ENVIRONMENTAL AND EQUIPMENT PERFORMANCE DATA WERE COLLECTED DURING A CROSSING OF THE GREENLAND ICECAP WITH OPERATION "LEAD DOG" (TRANSPORTATION CORPS), FROM CAMP TUTO TO WITHIN 20 MILES OF ICEFREE LAND IN PERRYLAND (NORTHEAST GREENLAND), WHERE FURTHER TRAVEL WAS BLOCKED BY THE CREVASSE ZONE.

#### (5) MOUNTAIN STUDIES

A REPORT ON THE EFFECT OF HUMAN ACTIVITIES, INCLUDING MILITARY CAMPAIGNS, ON THE VEGETATION OF THE MIDDLE APPALACHIAN MOUNTAINS WAS COMPLETED AND REPRODUCED ON MICROFILM. THIS REPORT IS AN EXPANSION OF ONE PART OF AN EARLIER QMC STUDY THAT WAS UNDERTAKEN TO DEVELOP A METHODOLOGY FOR FUTURE MOUNTAIN STUDIES. COLLATION AND SUMMARIZATION OF CLIMATIC DATA FROM A SERIES OF STATIONS IN THE FRONT RANGE OF COLORADO WAS CONTINUED UNDER A LEASE-AGREEMENT WITH THE UNIVERSITY OF COLORADO. WHEN A SUFFICIENTLY LONG RECORD HAS BEEN OBTAINED, THE DATA WILL BE USED TO DETERMINE ALTITUDINAL AND TEMPORAL VARIATIONS IN THE CLIMATE OF THE AREA. SOME OF THE DATA HAVE ALSO BEEN USED IN ECOLOGICAL STUDIES OF CERTAIN FORMS OF PLANT AND ANIMAL LIFE IN THE ROCKY MOUNTAINS.

#### (6) FREEZE-THAW CYCLES IN THE UNITED STATES AND CANADA

THE PHENOMENA OF ALTERNATE FREEZING AND THAWING IS A FINITE PHYSICAL PROCESS OCCURRING IN NATURE WHICH HAS A PROFOUND EFFECT ON THE NATURAL LANDSCAPE AND HENCE ON THE DESIGN AND OPERATION OF MILITARY EQUIPMENT. A TECHNIQUE FOR THE INVESTIGATION OF THE FREEZE-THAW CYCLE HAS BEEN DEVELOPED AND APPLIED TO THE UNITED STATES AND CANADA. IT WAS RELATIVELY SIMPLE TO REGIONALIZE THE PHENOMENA IN TERMS OF FREQUENCY, DURATION, SEVERITY, AND TIME OF YEAR.

EFFECTS OF THE FREEZE-THAW CYCLE ON THE NATURAL ENVIRONMENT INCLUDE THE RATE AT WHICH BEDROCK BREAKS DOWN, THE KIND OF SOIL WHICH IS FORMED, THE MASS MOVEMENTS OF THIS SOIL, AND ITS WATER RETENTION AND DRAINAGE CHARACTERISTICS. NATURAL VEGETATION MUST ADAPT ITSELF TO SUCH DIFFERENCES, AND THIS IS FOLLOWED BY CHANGES IN THE INSECT AND ANIMAL LIFE. THUS, QUITE DIFFERENT PHYSICAL ENVIRONMENTS MAY DEVELOP IN PLACES WHICH ARE UNLIKE IN THE FREEZE-THAW CYCLE BUT ALIKE IN OTHER IMPORTANT ASPECTS OF THE PHYSICAL ENVIRONMENT.

IN ADDITION TO THE SOMEWHAT INDIRECT EFFECTS OF THE FREEZE-THAW CYCLE IN THE FORMATION OF DIFFERENT ENVIRONMENTAL TYPES, THERE ARE SOME DIRECT

IMPLICATIONS FOR THE OPERATION OF MILITARY EQUIPMENT. THE EFFECT ON TRACTIONABILITY AND THE UPKEEP COST OF ROAD AND HARDSTAND SURFACES IS WELL KNOWN. ALTHOUGH NOT YET STUDIED, THE EFFECT OF FREEZING AND THAWING MUST ALSO BE INVESTIGATED WITH REGARD TO THE DESIGN AND ISSUE OF FOOTGEAR AND THE OPERATIONAL AND STORAGE LIFE OF MATERIEL AND EQUIPMENT CONTAINING WATER OR PERVIOUS TO WATER.

#### (7) FOOD GEOGRAPHY

A CONTRACT WITH THE AMERICAN GEOGRAPHICAL SOCIETY TO PREPARE A STUDY OF THE FOOD RESOURCES OF NORTHERN AFRICA AND SOUTHERN ASIA CONTINUED DURING THE YEAR. THIS STUDY DEVELOPS INFORMATION ON THE REGIONAL DISTRIBUTION OF DIET TYPES; THE KINDS, AMOUNTS, AND SUFFICIENCY OF FOOD (ANIMAL AND VEGETABLE) PRODUCED IN AN AVERAGE YEAR; THE FOOD IMPORTS IN AN AVERAGE YEAR; THE VULNERABILITY OF THE DIETARY STRUCTURE TO ENVIRONMENTAL HAZARDS AND HUMAN CATASTROPHES SUCH AS EPIDEMICS AND WAR; METHODS OF FOOD STORAGE, PROCESSING, AND PACKING; AND HEALTH AND/OR PHYSICAL DISABILITIES THAT MAY RESULT AS A CONSEQUENCE OF DIETARY INADEQUACIES AND PRACTICES. TO DATE, CHAPTERS HAVE BEEN COMPLETED ON MAINLAND CHINA AND TAIWAN, THAILAND, THE FEDERATION OF MALAYA, AND THE ARABIAN PENINSULA. THE CHAPTER ON BURMA IS NEARING COMPLETION; CHAPTERS ON INDIA, PAKISTAN, AND CEYLON ARE IN VARIOUS STAGES OF DEVELOPMENT.

#### (8) CLIMATIC FREQUENCY STUDIES

A CONTRACT WAS AWARDED MCGILL UNIVERSITY, MONTREAL, CANADA, FOR THE COLLATION, ANALYSIS, AND PRESENTATION OF AVAILABLE CLIMATIC FREQUENCY DATA (TEMPERATURE, WIND SPEED, COLD-WET CONDITIONS) FOR NORTHERN EURASIA AND NORTHERN NORTH AMERICA. THE DATA WILL BE PUBLISHED IN ATLASES CONTAINING TABLES AND MAPS OF CLIMATIC FREQUENCIES FOR 326 STATIONS THROUGHOUT THE NORTHERN PART OF THE NORTHERN HEMISPHERE. THESE WILL OUTLINE THE LOCATION AND FREQUENCIES OF CLIMATIC CONDITIONS WHICH MAY AFFECT OR LIMIT OPERATIONS OF PERSONNEL OR EQUIPMENT. THIS INFORMATION WILL BE USEFUL TO RESEARCH, DEVELOPMENT, AND ENGINEER PERSONNEL IN THE DESIGN AND DEVELOPMENT OF EQUIPMENT AND TO TEST PLANNERS IN THE SELECTION OF OPTIMUM PERIODS FOR TESTS OR OTHER MILITARY ACTIVITIES. TO DATE 4 VOLUMES CONTAINING TABLES OF TEMPERATURE AND WIND FREQUENCY DATA FOR EURASIA HAVE BEEN PUBLISHED; WORK IS CONTINUING ON THE PREPARATION OF MAPS SHOWING FREQUENCIES OF TEMPERATURE BELOW SELECTED LEVELS. FREQUENCY TABLES FOR NORTH AMERICA ARE BEING PREPARED AND WILL BE PUBLISHED IN 2 VOLUMES. THE AIR WEATHER SERVICE, USAF, HAS FURNISHED TABULATIONS OF CLIMATIC FREQUENCY DATA FOR 27 STATIONS IN AFRICA DURING THE YEAR; DATA FOR AN ADDITIONAL 75 STATIONS ARE EXPECTED BEFORE THE END OF THE CURRENT FISCAL YEAR.

#### (9) MACHINE STORAGE OF CLIMATIC AND GEOGRAPHIC DATA

RESEARCH WAS INITIATED IN 1956 TO DEVISE A SYSTEM FOR MACHINE STORAGE (BY DEGREE QUADRANGLE OF WORLD LAND AREA) OF MILITARILY SIGNIFICANT

CLIMATIC AND GEOGRAPHIC DATA WHICH WOULD PERMIT ITS RAPID UTILIZATION AS REQUIRED. CODING OF AVAILABLE DATA FOR SOUTHWEST ASIA IS COMPLETE AND EAM CARDS ARE BEING PREPARED FOR GREENLAND, CENTRAL EUROPE, AND THE UNITED STATES. FREQUENCY DATA FROM THE MATERIAL PREPARED BY MCGILL UNIVERSITY FOR NORTH AMERICA AND EURASIA WILL BE INCLUDED IN THE STORAGE SYSTEM WHERE APPROPRIATE. A REPORT DESCRIBING THE MACHINE STORAGE SYSTEM AND PROVIDING INSTRUCTIONS FOR THE PROCESSING AND STORAGE OF ENVIRONMENTAL DATA ON MAP OVERLAYS AND PUNCHED CARDS BY DEGREE QUADRANGLE OF WORLD LAND AREAS WAS PUBLISHED (1).

IN AN ATTEMPT TO EXPEDITE THE MAPPING PHASE OF THIS PROGRAM, ASSISTANCE IS BEING GIVEN BY U.S. ARMY RESERVE R&D UNITS. UNDER SR 140-190-2 AND AR 140-305 MAPPING ASSIGNMENTS MAY BE ACCOMPLISHED BY RESERVISTS FOR RETIREMENT-POINT CREDIT. THIRTY-FIVE RESERVISTS WERE TRAINED IN THE METHODS OF PLOTTING AND ANALYZING MAPS AND CODING THE DATA.

A CONTRACT WITH CLARK UNIVERSITY TO PREPARE EAM CARDS AND INDIVIDUAL MAP OVERLAYS FOR ENVIRONMENTAL CRITERIA (E.G., TEMPERATURE, PRECIPITATION, RADIATION, ETC.) FOR APPROXIMATELY 300 WEATHER STATIONS IN CENTRAL AFRICA CONTINUED DURING THE YEAR.

#### (10) HUMAN ENVIRONMENTS OF CENTRAL AFRICA

THE THREE-YEAR CONTRACT INITIATED IN SEPTEMBER 1958 WITH THE NATIONAL ACADEMY OF SCIENCES-NATIONAL RESEARCH COUNCIL, TO STUDY THE NATURAL AND CULTURAL ENVIRONMENTAL CONDITIONS THAT MIGHT AFFECT U.S. NATIONALS OPERATING IN CENTRAL AFRICA, HAS MADE RAPID PROGRESS DURING THE PAST YEAR. MOST OF THE SPECIAL TECHNICAL REPORTS PREPARED BY NOTED SCIENTISTS IN VARIOUS FIELDS UNDER SUB-CONTRACTS, ARE WELL ALONG TOWARDS COMPLETION. THE FIRST OF THESE REPORTS (18) WAS PUBLISHED, DEALING WITH THE EFFECTS OF THE NATURAL ENVIRONMENT UPON TRANSPORTATION IN FRENCH WEST AFRICA. AN ANALYSIS OF THE PHYSICAL GEOGRAPHY OF THE REGIONS OCCUPIED BY 10 REPRESENTATIVE TRIBES IS IN AN ADVANCED STAGE, AND A LARGE SUBCONTRACT WITH THE INTER-UNIVERSITY HUMAN RELATIONS AREA FILES, TO COLLECT DETAILED INFORMATION ON THE PHYSICAL AND CULTURAL ASPECTS OF THESE 10 TRIBAL AREAS, IS NOW READY FOR USE IN PREPARING THE FINAL REPORT OF THE CONTRACT. EIGHT ADDITIONAL TRIBES ARE BEING ANALYZED AT NO ADDITIONAL COST TO THE ARMY, IN CONNECTION WITH A RECENT GRANT FROM THE NATIONAL INSTITUTE OF HEALTH. A MANUSCRIPT, WITH 16 ORIGINAL MAPS, HAS BEEN COMPLETED ON FOOD DISTRIBUTIONS IN AFRICA, AND SEVERAL MANUSCRIPTS ARE READY FOR THE BOOK ON AFRICAN MARKETS. FIVE OF THE SENIOR SCIENTISTS HAVE SPENT TIME IN AFRICA DURING THE PAST YEAR TO OBTAIN INFORMATION FOR THEIR SUBCONTRACTS.

#### (11) SUPPORT TO SCIENTIFIC EXPEDITIONS

EACH YEAR REQUESTS FOR DEPARTMENT OF ARMY SUPPORT OF SCIENTIFIC EXPEDITIONS (SPONSORED BY ORGANIZATIONS OUTSIDE THE D/A) ARE EVALUATED AND FINANCIAL AND/OR LOGISTIC SUPPORT IS FURNISHED TO THOSE FROM



WHICH INFORMATION OR SERVICE OF VALUE TO THE ARMY CAN BE DERIVED. DURING FY-60, TWO EXPEDITIONS RECEIVING SUPPORT WERE APOLLONIO EXPEDITION TO ELLESMERE ISLAND AND THE DEVON ISLAND EXPEDITION.

THE APOLLONIO EXPEDITON, SPONSORED BY THE ARCTIC INSTITUTE OF NORTH AMERICA, CONDUCTED HYDROBIOLOGICAL RESEARCH NEAR ALERT, ELLESMERE ISLAND, TO PROVIDE QUANTITATIVE INFORMATION ON SUMMER PRIMARY ORGANIC PRODUCTIVITY OF FRESH AND SALT WATERS OF THE HIGH ARCTIC. REPORTS EMANATING FROM THIS EXPEDITION WILL PROVIDE A REASONABLY COMPLETE PICTURE OF ENERGY FLOW FROM SOLAR RADIATION THROUGH PRIMARY PRODUCERS TO HERBIVORES AND THE RELATED ENVIRONMENTAL FACTORS.

THE DEVON ISLAND EXPEDITION, ALSO SPONSORED BY THE ARCTIC INSTITUTE OF NORTH AMERICA, WILL CONDUCT AN EXTENSIVE SCIENTIFIC PROGRAM ON THE GLACIATED, NON-GLACIATED, AND MARINE ENVIRONMENTS DURING THE PERIOD 1960-1963. THE MAIN OBJECTIVES OF THIS EXPEDITION ARE:

1. A STUDY OF THE RELATIONSHIPS BETWEEN THE MARINE ENVIRONMENT, THE DEVON ISLAND ICECAP, AND THE ADJACENT ATMOSPHERE, WITH SPECIAL REGARD TO HEAT BUDGET, ENERGY FLOW, AND MOISTURE TRANSFER.

2. A DETAILED INVESTIGATION OF THE ARCHAEOLOGY, BIOLOGY, AND GEOLOGY OF DEVON ISLAND.

3. A DETAILED INVESTIGATION OF THE OCEANOGRAPHIC AND MARINE BIOLOGY OF JONES SOUND.

C. STUDIES OF ENVIRONMENT-EQUIPMENT INTERACTIONS

(1) ISSUE GUIDES

THE WORLD GUIDE TO FIELD CLOTHING REQUIREMENTS (COMPLETED IN 1957), WHICH SPECIFIED 9 WORLD REGIONS AND 4 UNIFORM COMBINATIONS, HAS BEEN INCORPORATED INTO A DRAFT TA 21 (MOBILIZATION) BY THE ARMY CLOTHING AND TEXTILE MATERIEL CENTER, PHILADELPHIA, AND IS BEING CIRCULATED AMONG APPROPRIATE ARMY AGENCIES FOR COMMENT. ACCEPTANCE OF THIS WOULD PROVIDE A NEW AND SIMPLIFIED PLAN FOR CLOTHING ISSUE.

A PRELIMINARY WORLD TENTAGE GUIDE, COMPOSED OF A WORLD MAP AND SEASONAL ISSUE TABLES, WAS PREPARED TO INDICATE THE MOST APPROPRIATE UTILIZATION, FROM AN ENVIRONMENTAL STANDPOINT, OF ARMY STANDARD COLD- AND HOT-WEATHER TENTS FOR ALL WORLD AREAS.

(2) INSECT DISTRIBUTION STUDIES

A KNOWLEDGE OF THE GEOGRAPHICAL DISTRIBUTION, SEASONAL ACTIVITY, AND HABITATS DURING THE BREEDING AND BITING STAGES OF INSECTS AND RELATED

PESTS IS REQUIRED FOR THE PLANNING OF ANTI-INSECT MEASURES. THE CONTINUING REPORTS OF RESISTANCE TO INSECTICIDES AND THE INCREASING NUMBER OF FIELD INVESTIGATIONS EMPHASIZE THE IMPORTANCE OF PROCESSING THE RESULTANT DATA INTO EASILY USABLE FORM.

DURING THE PAST YEAR DISTRIBUTION, SEASONAL, AND HABITAT INFORMATION ON INSECTS IN AFRICA WAS CONSOLIDATED INTO REPORTS FOR EACH COUNTRY. ADDITIONAL DATA ON BREEDING, POPULATION DENSITY, AND DISEASE RELATIONSHIPS WERE PUNCHED ON CARDS TO PROVIDE A RAPID MEANS OF OBTAINING INFORMATION CONCERNING THE INSECT CHARACTERISTICS OF ANY AFRICAN COUNTRY. THIS WORK SUPPLEMENTS THAT FOR NORTH AND SOUTH AMERICA, AUSTRALIA, AND ASIA, WHICH WAS PREVIOUSLY REPORTED. INFORMATION FURNISHED BY THESE STUDIES HAS BEEN APPLIED TO RESISTANCE AND CONTROL STUDIES IN BOTH MILITARY AND CIVILIAN AGENCIES DURING THIS PERIOD.

### (3) TEMPERATURE FACTORS IN FOOD STORAGE

TEMPERATURES IN FOUR DIFFERENTLY PROTECTED STORAGE-DUMP STACKS WERE STUDIED UNDER EXTREME HOT-DRY CONDITIONS ON DESERT TERRAIN AT YUMA, ARIZONA, DURING A 43-DAY PERIOD (11).

CARTON, AIR, AND FOOD TEMPERATURES WERE RECORDED BY THERMOCOUPLES AT CRITICAL LOCATIONS IN CARTONS IN STACKS EXPOSED IN THE FOLLOWING FOUR WAYS:

- (A) OPEN AND UNPROTECTED.
- (B) PROTECTED BY A RAISED PAULIN FLY.
- (C) PROTECTED BY A TIGHTLY-LASHED PAULIN.

(D) PROTECTED BY A RAISED PAULIN FLY WITH ADDITION OF REFLECTIVE FOIL LAID ON THE STACK SURFACE.

EACH STACK WAS COMPOSED OF 96 CARTONS OF ARMY C-RATIONS AND APPROXIMATED A 5-FOOT CUBE. AMBIENT TEMPERATURE AND RELATIVE HUMIDITY, WINDSPEED AND WIND DIRECTION, AND RADIATION WERE RECORDED 1/2 MILE FROM THE SITE.

EFFECTIVE STORAGE TEMPERATURE IN THE TIGHT PAULIN STACK FOR THE HOTTEST MONTH (JULY) WAS 102°F COMPARED TO ABOUT 90°F FOR THE OTHER STACKS. COMPARABLE TEMPERATURE IN A BOXCAR IS 103°F. EFFECTIVE STORAGE VALUES MAY BE USED FOR CONSTANT TEMPERATURE LABORATORY SIMULATION OF FIELD STORAGE STRESS.

### (4) MAN-EQUIPMENT-ENVIRONMENT RELATIONSHIPS

STUDIES OF THE RELATIONSHIPS BETWEEN ENVIRONMENT AND MILITARY ACTIVITIES IN CERTAIN MAJOR REGIONS OF THE WORLD, AND METHODS OF GRAPHICALLY PORTRAYING THESE RELATIONSHIPS CONTINUED. A REPORT (8) WAS PUBLISHED ON SOUTHWEST ASIA DEALING WITH RELATIONSHIPS BETWEEN THE ENVIRONMENT AND

THE SOLDIER, AND RELATIONSHIPS BETWEEN THE ENVIRONMENT AND MATERIEL ARE SHOWN ON MAPS AND GRAPHS. MOST OF THE MILITARY PROBLEMS OF THE REGION ARE CAUSED BY EXCESSIVE HEAT AND ARIDITY, ALTHOUGH THE COMBINATION OF HEAT AND HIGH HUMIDITY NEAR THE PERSIAN GULF AND THE RED SEA CAUSE EXTREME DISCOMFORT AT TIMES IN THESE PARTICULAR AREAS. IN MUCH OF THE REGION, SUMMER HEAT CAUSES IMPAIRMENT OF MAN'S ABILITY TO WORK AND INCREASES HIS WATER REQUIREMENTS. THE ENVIRONMENT ALSO CAUSES STORAGE AND OPERATING DIFFICULTIES.

A SIMILAR REPORT IS BEING PREPARED FOR AFRICA AND ANOTHER BEGUN FOR THE NORTH POLAR REGIONS. THE POLAR STUDY WILL BE PRIMARILY DIRECTED TOWARD REPRESENTING FACTORS WHICH WOULD AFFECT LANDING OF AIRCRAFT AT UNPREPARED SITES.

#### (5) LIAISON AND COORDINATION ACTIVITIES

IN THE EXERCISE OF ITS COGNIZANCE, THE QUARTERMASTER CORPS HAS PARTICIPATED ACTIVELY IN LIAISON AND COORDINATION ACTIVITIES DEALING WITH ENVIRONMENTAL CRITERIA FOR DESIGN AND TESTING WHICH ARE MORE FULLY DESCRIBED IN CHAPTER I OF THIS REPORT. SPECIFIC CONTRIBUTIONS INCLUDE:

(A) THE DISTRIBUTION OF A REPORT ENTITLED "DEPARTMENT OF DEFENSE ENGINEERING GUIDANCE PROGRAM IN THE ENVIRONMENTAL FIELD."

(B) CONTRIBUTIONS OF MASTER OUTLINES FOR CHAPTER IIA, "DESCRIPTION OF LAND ENVIRONMENTS," AND CHAPTER III, "ENVIRONMENTAL CRITERIA," OF A PROPOSED DOD ENVIRONMENTAL HANDBOOK. ALSO, COMMENTS WERE GATHERED FROM OTHER TECHNICAL SERVICES AND INCORPORATED IN CHAPTER I, "GLOSSARY OF ENVIRONMENTAL TERMINOLOGY FOR USE IN DESIGN-DEVELOPMENT TESTING."

### 2. CORPS OF ENGINEERS

#### A. ARMY MOBILITY RESEARCH CENTER

THE U.S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION, OPERATING UNDER PROJECT 8-70-00-000, GROUND MOBILITY RESEARCH, IS CONDUCTING STUDIES OF OFF-ROAD MOVEMENT OF MILITARY VEHICLES UNDER THE TWO GENERAL AREAS, TRAFFICABILITY AND VEHICLE MOBILITY RESEARCH. TRAFFICABILITY STUDIES ARE DIRECTED TOWARD DEVELOPMENT OF INSTRUMENTS AND TECHNIQUES FOR CONTACT MEASUREMENT OR REMOTE ESTIMATE OF THE ABILITY OF SOIL AND SNOW TO PERMIT THE PASSAGE OF EXISTING MILITARY VEHICLES. INSTRUMENTS FOR THE CONTACT MEASUREMENT OF THE TRAFFICABILITY OF SOILS ARE PRESENTLY BEING STANDARDIZED, AND A REPORT (20) WAS PUBLISHED WITH INSTRUCTIONS FOR PROPER USE OF THE INSTRUMENTS BY TROOPS IN THE FIELD.

VEHICLE MOBILITY RESEARCH IS BEING CONDUCTED USING A RECENTLY COMPLETED TEST FACILITY. INVESTIGATIONS ARE IN PROGRESS ON THE PHYSICAL RELATIONSHIPS

BETWEEN THE WHEELS OR TRACKS OF MOVING VEHICLES AND THE SOILS ON WHICH THEY MOVE. DATA DERIVED FROM THESE INVESTIGATIONS WILL SERVE AS A BASIS FOR THE DEVELOPMENT OF RATIONAL METHODS FOR DESIGNING VEHICLES WITH IMPROVED MOBILITY CHARACTERISTICS.

#### B. MILITARY EVALUATION OF GEOGRAPHIC AREAS

THE MAJOR OBJECTIVE OF THE CORPS OF ENGINEERS PROJECT, "MILITARY EVALUATION OF GEOGRAPHIC AREAS," IS TO DEVELOP METHODS OF CLASSIFYING AND COMPARING GEOGRAPHIC AREAS IN TERMS OF THE EFFECTS OF THE NATURAL AND MAN-MODIFIED ENVIRONMENT UPON MILITARY ACTIVITIES. IN ACCOMPLISHING THIS OBJECTIVE, TWO INTERMEDIATE STEPS ARE NECESSARY: FIRST, TO DEFINE CRITICAL ENVIRONMENTAL FACTORS AND EFFECTS THROUGH STUDY OF HISTORICAL RECORDS AND OTHER SOURCES; SECOND, TO ESTABLISH CONSISTENT, OBJECTIVE, AND AS FAR AS POSSIBLE, QUANTITATIVE CLASSIFICATIONS OF TERRAIN AND CLIMATIC CHARACTERISTICS, SO THAT AREAS CAN BE DESCRIBED IN COMMON TERMS.

THE DETERMINATION OF CRITICAL FACTORS HAS INCLUDED AN EXTENSIVE STUDY OF WORLD WAR II AND KOREAN WAR OPERATIONAL RECORDS CONSISTING PRIMARILY OF DIVISIONAL RECORDS AND AFTER-ACTION REPORTS. THIS WORK IS BEING EXTENDED TO STUDY OF MANEUVER REPORTS, USER TEST REPORTS, AND OTHER MILITARY RECORDS.

THE DEVELOPMENT OF UNIVERSAL CLASSIFICATION SYSTEMS FOR PURPOSES OF COMPARING AREAS IS BEING ACCOMPLISHED THROUGH STUDIES OF ARMY TEST SITES AT YUMA, ARIZONA; FORT CHURCHILL, CANADA; FORT GREELY, ALASKA; AND THE PANAMA CANAL ZONE. REPORTS HAVE BEEN PREPARED ON FIELD STUDIES MADE IN THESE AREAS. THE QUARTERMASTER CORPS IS COOPERATING WITH THE CORPS OF ENGINEERS IN CONDUCTING ANALOG STUDIES COMPARING THE CLIMATES OF THESE TEST SITES WITH OTHER WORLD AREAS, AND A NUMBER OF REPORTS HAVE BEEN PREPARED. TERRAIN ANALOG STUDIES ARE BEING MADE BY VARIOUS CORPS OF ENGINEERS ORGANIZATIONS AND BY UNIVERSITIES UNDER CONTRACTUAL ARRANGEMENTS.

#### C. RELATED PROGRAMS

THE TASK, INITIATED AS PART OF THE COLD REGIONS RESEARCH PROJECT TO DEVELOP AND ESTABLISH CRITERIA AND TECHNICAL GUIDANCE FOR SITE SELECTION, DESIGN, LAYOUT, CONSTRUCTION, AND MAINTENANCE OF CAMPS AND BASES TO MINIMIZE THE EFFECTS OF ENVIRONMENT IN COLD REGIONS, AND TO DEVELOP IMPROVED CRITERIA FOR DESIGN OF MATERIEL AND EQUIPMENT FOR USE IN COLD REGIONS, IS BEING CONTINUED.

TESTING OF CORPS OF ENGINEERS EQUIPMENT AND MATERIALS IS CONTINUING IN LABORATORY FACILITIES AT FORT BELVOIR, AND IN THE FIELD AT YUMA TEST STATION, FORT CHURCHILL, AND OTHER FIELD ESTABLISHMENTS IN MICHIGAN, ALASKA, AND THE CANAL ZONE. EQUIPMENT FIELD-TESTED DURING THE CURRENT FISCAL YEAR INCLUDES SUCH DIVERSE ITEMS AS SMALL MILITARY STANDARD GASOLINE ENGINE,

AERIAL MINE LAYING AND CLEARING EQUIPMENT, HOSELINE PUMPING UNIT, A RUBBER-TIRED DITCHING MACHINE, AND TITANIMUM PONTONS. FIELD EXPOSURES AT THE ARCTIC, DESERT, AND TROPIC TEST SITES WERE STARTED OR CONTINUED ON SUCH ITEMS AS PROTECTIVE COATINGS, INCLUDING FIRE-RETARDANT PAINT, CORROSION-INHIBITING PRESERVATIVES, SANDBAG FABRICS, AND FUNGICIDAL POINTS.

### 3. ORDNANCE CORPS

ENVIRONMENTAL RESEARCH IN THE ORDNANCE CORPS CONCENTRATES HEAVILY ON THE FIELD TESTING OF EQUIPMENT IN SEVERE ENVIRONMENTS. RESULTS OF TESTS ARE SYSTEMATICALLY RECORDED AND PERFORMANCE CAPABILITIES OF EQUIPMENT ARE FREQUENTLY UP-DATED. FIELD TESTS CALL ATTENTION TO GAPS IN ENVIRONMENTAL KNOWLEDGE AND LEAD TO THE UNDERTAKING OF RESEARCH IN THESE AREAS.

#### A. ENVIRONMENTAL RESEARCH

##### (1) DUST

A TECHNIQUE WAS DEVELOPED FOR MEASURING THE DUST PRODUCING CAPABILITY OF A SOIL, BASED ON DATA OBTAINED FROM ANALYSES OF SOIL SUBJECTED TO VEHICLE TIRE ACTION AND FROM UNDISTURBED SOIL ANALYZED IN THE LABORATORY. QUARTZ SAND WAS THE FIRST SOIL CHOSEN FOR SCRUTINY AND TECHNIQUE DEVELOPMENT BECAUSE IT EXHIBITS PROPERTIES OF HARDNESS, SLOW WATER ATTACK, AND WORLD-WIDE AVAILABILITY. FOR THE OPPOSITE INHERENT SOIL CHARACTERISTICS, A SOFT LIMESTONE SOIL HAVING HIGH FRAGMENTATION PROPERTIES WAS SELECTED. SOIL BINS WERE FABRICATED FOR SAMPLING EVALUATIONS AND A SITE ON THE INSTITUTE GROUNDS (SAN ANTONIO, TEXAS) WAS CHOSEN FOR CONDUCTING THE SOIL BREAKDOWN STUDIES.

##### (2) WHITEOUT

THE OCCURRENCE OF WHITEOUT CONDITIONS IN GREENLAND AND OTHER ARCTIC AREAS SEVERELY HAMPER BOTH AIR AND LAND OPERATIONS. IN FACT, WHITEOUT IS PROBABLY RESPONSIBLE FOR GREATER CURTAILMENT OF OPERATIONS THAN ANY OTHER CAUSE, INCLUDING MECHANICAL FAILURES.

FEASIBILITY INVESTIGATION OF WHITEOUT MODIFICATION WAS SUBCONTRACTED TO THE CORNELL AERONAUTICAL LABORATORY, INC. FIVE ICECAP WHITEOUTS WERE SAMPLED, FOUR OF WHICH APPEARED SUITABLE FOR ALTERATION BY CURRENT CLOUD DISSIPATION TECHNIQUES. A PILOT STUDY OF FISTCLENCH WEATHER DATA REVEALED THE WHITEOUT PROBLEM TO BE OF EXTENSIVE PROPORTIONS, WITH WHITEOUTS OCCURRING ON APPROXIMATELY 50% OF THE OBSERVATION DAYS. OF THESE, HALF WERE OF THE LESS CRITICAL OVERCAST-CLOUD VARIETY. RECORDED TEMPERATURE DATA INDICATED THAT A MAJORITY OF THE FISTCLENCH WHITEOUTS WOULD RESPOND TO SEEDING WITH DRY ICE; SILVER IODIDE SHOULD BE APPLICABLE IN A QUARTER OF THE CASES. PRELIMINARY SERIES OF SEEDING EXPERIMENTS WERE RECOMMENDED TO BE CONDUCTED IN GREENLAND TO EVALUATE ACTUAL WHITEOUT MODIFICATION CAPABILITY; RESULTS

OF THE INITIAL TESTS WOULD DETERMINE THE FEASIBILITY OF THE U.S. ARMY ESTABLISHING AN OPERATIONAL SEEDING PROGRAM. THESE FINDINGS HAVE BEEN COORDINATED WITH SIPRE TO THE END OF MUTUALLY SUPPORTING AN APPLIED RESEARCH PROGRAM ON A BROADER SCALE IN 1960.

### (3) OTHER STUDIES OF THE ENVIRONMENT

RESEARCH IS PROCEEDING IN SEVERAL OTHER AREAS OF SPECIAL INTEREST TO THE ORDNANCE CORPS. AMONG THE MOST IMPORTANT OF THESE ARE ABRASIVENESS OF SOILS AND THE DYNAMIC LOADING OF SOILS BY WEAPON MOUNTS.

#### B. ENVIRONMENTAL FACTORS INDEX AND CHARTS

##### (1) ENGINEERING AND USER TESTING

FIELD ENVIRONMENTAL ENGINEERING TESTS ARE CONDUCTED BY THE ORDNANCE CORPS UNDER PLANNED TEST PROGRAMS, BOTH IN SUMMER AND WINTER (IN WINTER IN THE NORTH TEMPERATE ARCTIC ZONES AND IN SUMMER IN THE DESERT AREAS) TO PROVIDE OPPORTUNITY FOR OBSERVATION AND TESTING OF COMPONENT MATERIEL, MAJOR ITEM COMPONENTS, AND PROTOTYPES OF MAJOR END ITEMS UNDER CONSIDERATION OR IN PRODUCTION. A LIMITED AMOUNT OF DATA IS OBTAINED THROUGH OBSERVATION OF USER TESTS MADE BY USCONARC AND FROM REPORTS RECEIVED FROM COMBAT AREAS. IN THE NORTH TEMPERATE ZONE ARCTIC TESTS, PARTICULAR ATTENTION IS PAID TO MOBILITY IN SOFT, DEEP SNOW, AND COLD STARTING (28) AND WARM-UP OF VEHICLES. IN TROPICAL DESERT TESTS, ITEMS ARE TESTED FOR RESISTANCE TO DUST AND SAND, FOR ABILITY OF ENGINES TO OPERATE FREE OF VAPOR LOCK AND TO COOL PROPERLY, AND FOR MOBILITY IN THE SAND DUNES. CAREFULLY PLANNED PROGRAMS ARE DEVISED TO PUT EACH COMPONENT TO THE MOST RIGOROUS TEST POSSIBLE, CONSISTENT WITH SERVICE REQUIREMENTS. TEST AGENCIES USED DURING THIS REPORTING PERIOD WERE AS FOLLOWS:

(A) U.S. ARMY ORDNANCE CLIMATIC TEST DETACHMENT, FORT CHURCHILL, MANITOBA, CANADA.

(B) U.S. ARMY ORDNANCE TEST ACTIVITY, YUMA TEST STATION, YUMA ARIZONA.

(C) U.S. ARMY ARCTIC TEST BOARD, FORT GREELY, ALASKA.

NOTE: LISTING OF ALL FORMAL REPORTS FOR INDIVIDUAL MATERIEL IS TO BE NOTED IN ANNUAL R&D PROGRESS REPORT UNDER PROJECT 5B98-09-004.

##### (2) LISTING AND ABSTRACTING

LISTING AND ABSTRACTING OF REPORTS AND PUBLICATIONS FROM ALL SOURCES, DESCRIBING THE EFFECTS OF VARIOUS ENVIRONMENTAL FACTORS ON THE OPERATION AND MAINTENANCE OF ORDNANCE MATERIEL, CONTINUED AT ABERDEEN

PROVING GROUND (ORDBG-DP-DF) FOR THE BIBLIOGRAPHICAL INDEX KNOWN AS THE ORDNANCE TECHNICAL INDEX OF ENVIRONMENTAL FACTORS, UNDER CONTRACT No. DA-23-072-509-ORD-4 WITH THE SOUTHWEST RESEARCH INSTITUTE (ENVIRONMENTAL RESEARCH SECTION). REVISED AND REBOUND ISSUES OF THE INDEX WERE PREPARED AS OF JULY 1959 FOR THE SECTION DESCRIBED AS "COLD" (PART I, VOLS. I AND II), AND "HOT" (PART II), "TROPICAL" (PART III), AND "HIGH ALTITUDE" (PART IV), ALL IN ONE VOLUME. SUPPLEMENTS ARE PREPARED AND DISTRIBUTED ANNUALLY TO COMPRISE, CURRENTLY, SEVERAL THOUSAND ABSTRACTS.

### (3) ENVANAL

THE REFERENCED CONTRACT ALSO ENCOMPASSES TECHNICAL AND SCIENTIFIC RESEARCH IN CONNECTION WITH THE COMPILATION OF SUMMARY CHARTS TO PRESENT THE STATUS OF ORDNANCE CORPS ENVIRONMENTAL TESTS AND FEATURE THE ORDNANCE CORPS ENVANAL PROGRAM. THE RELATED PUBLICATION, "U.S. ARMY ORDNANCE CORPS ENVANAL CHARTS, SELF-PROPELLED AUTOMOTIVE EQUIPMENT, DESERT," WAS COMPLETED AT THE CLOSE OF 1959 AS THE FIRST OF CURRENT REANALYSIS SERIES IN THE MAJOR CATEGORIES OF AUTOMOTIVE, AMMUNITION, AND WEAPONS. THE NEXT TO FOLLOW WILL BE "U.S. ARMY ORDNANCE CORPS ENVANAL CHARTS, SELF-PROPELLED AUTOMOTIVE EQUIPMENT, ARCTIC, 1960."

### 4. CHEMICAL CORPS

THE CHEMICAL CORPS CONTINUED ENVIRONMENTAL RESEARCH AND TESTING AT ITS FIVE SITES LOCATED IN EACH OF THE MAJOR CLIMATES OF THE WORLD. THESE SITES ARE ADMINISTERED FROM THE U.S. ARMY CHEMICAL CORPS PROVING GROUND, DUGWAY PROVING GROUND, DUGWAY, UTAH. THEIR LOCATIONS ARE: FORT GREELY, ALASKA, ARCTIC; YUMA TEST STATION, ARIZONA, DESERT; CAMP TUTO, GREENLAND, POLAR; FORT CLAYTON, CANAL ZONE, TROPIC; AND ARMY CHEMICAL CENTER, MARYLAND, TEMPERATE. AN ACCELERATED EFFORT WAS LAUNCHED DURING THE YEAR DESIGNED TO FILL KNOWLEDGE GAPS IN CBR COLD-WEATHER OFFENSIVE AND DEFENSIVE DOCTRINE.

#### A. MICROMETEOROLOGICAL RESEARCH

AS PART OF ITS CONTINUING EFFORT TO PROVIDE FIRM GUIDANCE IN DOCTRINAL AND TECHNICAL AREAS, THE CHEMICAL CORPS CONTINUED RESEARCH ON THE EFFECTS OF DIFFERENT ATMOSPHERIC CONDITIONS ON CBR WARFARE. DATA ON WINDSPEED AND DIRECTION, TEMPERATURE (6 LEVELS), DEW POINT, AND ATMOSPHERIC PRESSURE ARE CHanneLED TO THE U.S. ARMY CHEMICAL CORPS PROVING GROUND FOR COMPILATION AND ANALYSIS. IN ADDITION, ACTUAL FIELD TRIALS ARE CONDUCTED TO DETERMINE THE EFFECT OF ATMOSPHERIC CONDITIONS IN THE VARIOUS ENVIRONMENTS (SUCH AS FOREST CANOPY, MOUNTAIN-VALLEY TERRAIN, SNOW PLAINS, ETC.) ON THE USE AND EFFECTIVENESS OF VARIOUS DISSEMINATING SYSTEMS.

#### B. ENVIRONMENTAL TESTING

THE ENVIRONMENTAL TESTING PROGRAM WHICH IS DESIGNED TO ASSURE THAT THE CHEMICAL CORPS ITEMS HAVE AN ALL-WEATHER CAPABILITY, CONTINUED. IN

THIS WORK THE CAPABILITY OF CHEMICAL CORPS ITEMS TO WITHSTAND STORAGE AND TO FUNCTION IN ALL ENVIRONMENTS REPRESENTED AT EACH OF THE TEST SITES IS ESTABLISHED. ONE HUNDRED AND THIRTEEN ITEMS HAVE BEEN TESTED IN THIS PROGRAM AND 35 ITEMS ARE CURRENTLY IN TEST.

IN CONJUNCTION WITH THE TESTING OF CHEMICAL CORPS ITEMS TO DETERMINE THEIR ALL-WEATHER CAPABILITIES, TESTS ARE ALSO DESIGNED TO OBTAIN BASIC DATA ON OPERATIONAL CONCEPTS FOR USE OF THE ITEM AND ON ITS EFFECTIVENESS IN THE VARIOUS ENVIRONMENTS (E.G., IN TESTS OF THE M3A3 SMOKE GENERATOR ON THE GREENLAND ICECAP, DATA OBTAINED IN THE BEHAVIOR OF THERMALLY GENERATED SMOKE CLOUDS GAVE NEW INSIGHT INTO THE CAPABILITIES AND LIMITATIONS OF THE USE OF VISUAL COMBAT SURVEILLANCE COUNTERMEASURES IN THIS TYPE OF ENVIRONMENT). FIGURE 5 DEPICTS HOW THE METEOROLOGICAL CONDITIONS CHARACTERISTIC OF THE POLAR REGION AND THE SNOW AND ICE PLAIN APPEAR TO MINIMIZE DISPERSION OF SMOKE CLOUDS AND CAUSE THE SMOKE PLUMES TO FOLLOW CURIOUS PATTERNS.

AT THE CLOSE OF THE PERIOD, CHEMICAL CORPS REPRESENTATIVES WERE PARTICIPATING IN THE TRANSPORTATION CORPS' OPERATION LEAD DOG IV, WHICH IS A RESEARCH EXPEDITION ACROSS THE GREENLAND ICECAP BY OVER-SNOW TRAIN. THE EFFECTIVENESS OF EXISTING CBR DEFENSIVE EQUIPMENT, EFFECT OF LONG-CONTINUED WEARING OF PROTECTIVE MASKS UPON PERSONNEL, AND EFFECTIVENESS OF SIGNALLING SMOKES (ESPECIALLY DURING PERIODS OF "OVERCAST WHITEOUTS") ARE BEING INVESTIGATED IN THE POLAR ENVIRONMENT.

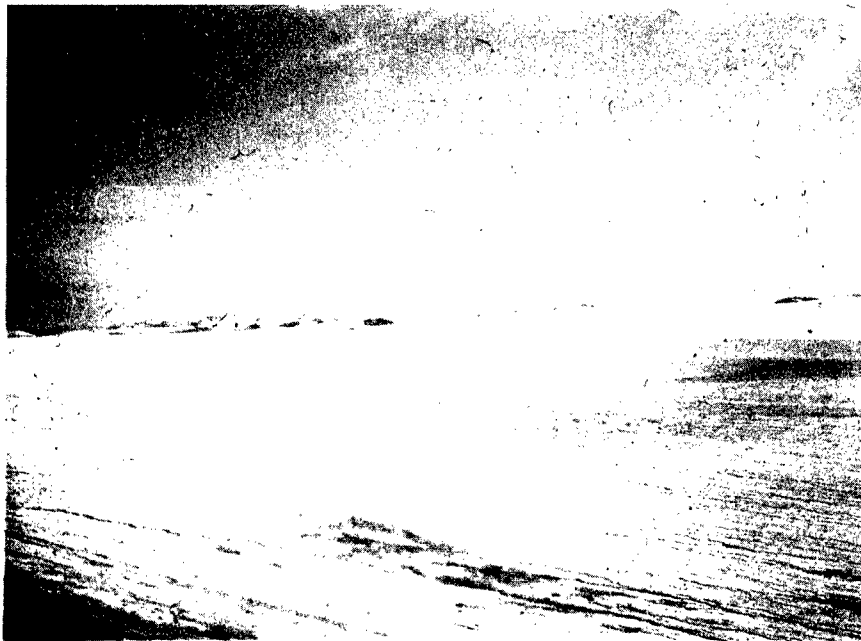


FIGURE 5. CHEMICAL SMOKE CLOUD ON THE GREENLAND ICECAP. THE SMOKE BECOMES CHanneled INTO LOW SPOTS AND FAILS TO RISE.



## 5. ARMY MEDICAL SERVICE

### A. THE EFFECT OF COMBINATIONS OF WIND VELOCITY AND TEMPERATURE ON COOLING RATES

RESEARCH WAS INITIATED IN 1957 TO STUDY MORE CLOSELY THE COOLING RATE OF COMBINATIONS OF WIND AND TEMPERATURE. AT FIRST THE RESEARCH CONSISTED OF INVESTIGATIONS USING PHYSICAL SYSTEMS IN ORDER TO ARRIVE AT MATHEMATICAL PRINCIPLES INVOLVED IN THIS PROBLEM. VARIOUS FORMULAE WERE EVOLVED CONCERNING CERTAIN PATTERNS OF COOLING. THE SYSTEMS FORMULATED WERE THEORETICALLY APPLIED TO COOLING RATES OF PHYSICAL SYSTEMS WHOSE THERMAL CHARACTERISTICS CLOSELY APPROACHED THOSE OF LIVING TISSUE. DURING THE FISCAL YEAR, THE COOLING PATTERNS OF THE LITTLE FINGER OF HUMANS WERE ALSO STUDIED UNDER VARIOUS COMBINATIONS OF WIND AND TEMPERATURE. CURRENTLY, FURTHER STUDIES ARE BEING CARRIED OUT TO INVESTIGATE DISCREPANCIES BETWEEN EXPERIMENTAL AND THEORETICAL RESULTS.

### B. COLD INJURY STUDIES

INVESTIGATIONS CONCERNED WITH METHODS OF INCREASING RESISTANCE TO COLD INJURY WERE INITIATED IN 1957 BASED UPON THE RESULTS OBTAINED IN ANIMALS. THESE DEMONSTRATED THAT ACCLIMATIZATION TO COLD PRODUCED A DRAMATIC INCREASE IN RESISTANCE TO COLD INJURY. THE PHYSIOLOGICAL CHANGES ASSOCIATED WITH THIS INCREASE IN RESISTANCE WERE MORE CLOSELY DEFINED. STUDIES WERE AND ARE BEING CARRIED OUT TO DETERMINE WHETHER SIMILAR RELATIONSHIPS BETWEEN INCREASED RESISTANCE TO COLD INJURY AND ACCLIMATIZATION EXIST IN MAN. IT HAS BEEN SHOWN THAT PHYSIOLOGICAL CHANGES DO TAKE PLACE IN MAN AS A RESULT OF ACCLIMATIZATION TO COLD, BOTH IN THE LABORATORY AND IN THE FIELD. THE FIELD STUDIES DURING THE FISCAL YEAR WERE CARRIED OUT IN ALASKA WHILE THE LABORATORY STUDIES WERE CARRIED OUT BY THE DIVISION OF ENVIRONMENTAL MEDICINE, USAMRL, FORT KNOX, KENTUCKY. INCREASED RESISTANCE TO COLD INJURY HAS BEEN DEMONSTRATED BY THE FACT THAT EXTREMITIES EXPOSED TO FROST-BITE TEMPERATURES SHOW A DECREASED RATE OF COOLING IN ACCLIMATIZED INDIVIDUALS AS COMPARED WITH NON-ACCLIMATIZED PERSONS. VARIOUS STUDIES HAVE BEEN CARRIED OUT TO DETERMINE THE RETAINABILITY OF COLD ACCLIMATIZATION AND THE FACTORS WHICH INFLUENCE THIS RETENTION. IT HAS BEEN SHOWN THAT THOSE INDIVIDUALS WHO HAVE BEEN DELIBERATELY ACCLIMATIZED BY NUDE EXPOSURE RETAIN THEIR COLD ACCLIMATIZATION FOR PERIODS OF UP TO 18 MONTHS; THAT THE COLD ACCLIMATIZATION SO DEVELOPED IS UNAFFECTED BY HEAT ACCLIMATIZATION OR BY THE NATURAL HEAT OF THE SUMMER MONTHS.

## 6. SIGNAL CORPS

### A. METEOROLOGICAL SUPPORT TO ARMY RESEARCH AND DEVELOPMENT ACTIVITIES

SIGNAL CORPS METEOROLOGICAL PERSONNEL OPERATE OBSERVING NETWORKS AND COLLECT METEOROLOGICAL DATA IN SUPPORT OF THE ENVIRONMENTAL RESEARCH

PROGRAMS OF THE VARIOUS TECHNICAL SERVICES. THESE METEOROLOGICAL DATA COLLECTION NETWORKS WERE OPERATED DURING FISCAL YEAR 1960 FOR THE QUARTERMASTER CORPS AT NATICK AND MAYNARD, MASSACHUSETTS, PUERTO RICO, AND FORT BENNING, GEORGIA. THEY WERE OPERATED FOR THE CHEMICAL CORPS AT FORT GREELY, ALASKA, DUGWAY PROVING GROUND, UTAH, YUMA TEST STATION, ARIZONA, ARMY CHEMICAL CENTER, MARYLAND, AND FORT CLAYTON, CANAL ZONE. IN ADDITION, THE SIGNAL CORPS METEOROLOGICAL TEAMS ARE OPERATING DATA COLLECTION NETWORKS IN GREENLAND, AT FORT MONMOUTH, NEW JERSEY, AND AT FORT HUACHUCA, ARIZONA.

#### B. METEOROLOGICAL RESEARCH

UNDER ITS ASSIGNMENT OF PRIMARY COGNIZANCE FOR RESEARCH AND DEVELOPMENT IN THE FIELD OF METEOROLOGY (APPENDIX 1), THE SIGNAL CORPS IS CONDUCTING SEVERAL PROGRAMS, THE RESULTS OF WHICH WILL CONTRIBUTE SIGNIFICANTLY TO A BETTER UNDERSTANDING OF THE ENVIRONMENT AND TO THE ARMY'S FUTURE CAPABILITY FOR CONDUCTING ENVIRONMENTAL RESEARCH. THESE PROGRAMS ARE BRIEFLY DESCRIBED BELOW:

##### (1) ARCTIC METEOROLOGICAL RESEARCH

AN ACTIVE RESEARCH PROGRAM IS BEING CONDUCTED IN ARCTIC METEOROLOGY WITH THE AIM OF IDENTIFYING AND UNDERSTANDING METEOROLOGICAL CONDITIONS THAT PERTAIN TO THESE LITTLE-KNOWN AREAS. DUE TO LIMITATIONS ON FUNDS AND PERSONNEL DURING FISCAL YEAR 1960, THIS PROGRAM WAS CONFINED LARGELY TO THE GREENLAND AREA. SPECIAL ATTENTION IS BEING GIVEN TO LOW LEVEL WIND STRUCTURE OVER THE GREENLAND ICECAP AND TO TECHNIQUES FOR LOCATING AND IDENTIFYING CAMP SITES BY ANALYSIS OF ATMOSPHERIC CONTAMINATION. UPPER ATMOSPHERIC CONDITIONS ARE ALSO BEING STUDIED FOR THIS AREA.

##### (2) TROPICAL METEOROLOGICAL RESEARCH

THE FIRST PHASE OF A TROPICAL METEOROLOGICAL RESEARCH PROGRAM WAS INITIATED WHICH, LIKE THAT OF THE ARCTIC RESEARCH PROGRAM, IS AIMED AT IDENTIFYING AND UNDERSTANDING THE METEOROLOGICAL CONDITIONS THAT EXIST IN RELATIVELY UNKNOWN AREAS OF THE WORLD. THIS PROJECT WILL EMPHASIZE LOCAL METEOROLOGICAL EFFECTS IN TROPICAL AREAS, THUS ASSISTING IN THE ESTABLISHMENT AND IDENTIFICATION OF DETAILS OF THE ENVIRONMENT FOR DIFFERENT TYPES OF TROPICAL REGIONS; I.E., RAINY TROPICS, WET-DRY TROPICS, MONSOON TROPICS, TROPICAL DESERTS, AND TROPICAL HIGHLANDS.

##### (3) UPPER ATMOSPHERE STUDIES

THE SIGNAL CORPS, IN COOPERATION WITH THE U.S. NAVY, NASA, AND THE U.S. AIR FORCE, IMPLEMENTED THE FIRST PHASES OF A METEOROLOGICAL ROCKET NETWORK DESIGNED TO COLLECT METEOROLOGICAL DATA IN THAT LAYER OF THE ATMOSPHERE ABOVE NORMAL BALLOON SOUNDINGS (100,000 FEET) AND BELOW

NORMAL SATELLITE SOUNDINGS. PERIODIC FIRINGS OF METEOROLOGICAL ROCKETS WERE BEGUN AT THE PACIFIC MISSILE RANGE, PT. MUGU, CALIFORNIA, FORT GREELY, ALASKA, FORT CHURCHILL, CANADA, AND WALLOPS ISLAND, VIRGINIA. ADDITIONAL FIRINGS WERE INITIATED DURING THE LATTER PART OF THE FISCAL YEAR AT WHITE SANDS MISSILE RANGE, NEW MEXICO, AND TONOPAH, NEVADA. EVENTUALLY, AS THIS METEOROLOGICAL ROCKET NETWORK OPERATION IS IMPROVED, ITS RESULTS WILL BE USED IN PREPARING A CLIMATOLOGY OF THE HIGH LEVEL ATMOSPHERE BETWEEN 100,000 AND 300,000 FEET. ATMOSPHERIC CONDITIONS AT THESE LEVELS ARE NOT ONLY AN IMPORTANT ENVIRONMENTAL AREA, PER SE, AS WE ADVANCE INTO THE SPACE AGE, BUT THEY HAVE AN IMPORTANT BEARING ON THE CONTROLS OF ENVIRONMENT AT LOWER LEVELS EXTENDING EVEN TO THE SURFACE OF THE EARTH.

#### (4) SMALL-SCALE METEOROLOGICAL RESEARCH

ACTIVE BASIC RESEARCH PROGRAMS IN SMALL-SCALE (MICRO- AND MESO-) METEOROLOGY ARE ALSO BEING CONDUCTED. WHILE THESE PROGRAMS ARE LIMITED LARGELY TO BASIC RESEARCH INTO THE PHYSICAL PROCESSES OF SMALL-SCALE METEOROLOGY, THE ULTIMATE UNDERSTANDING OF THESE PROCESSES WILL OPEN THE WAY TO A MUCH BETTER UNDERSTANDING OF THE LOCAL VARIATIONS IN ENVIRONMENT WHICH ARE EXPERIENCED AND TO A MUCH BETTER SYSTEM OF IDENTIFYING AND CHARACTERIZING THE MORE MINUTE BUT SIGNIFICANT DETAILS OF ENVIRONMENT. THUS THE ENVIRONMENTAL RESEARCH PROGRAM OF THE U.S. ARMY WILL BE GREATLY FACILITATED BY RESULTS FROM THE SIGNAL CORPS RESEARCH PROGRAMS IN SMALL-SCALE METEOROLOGY.

#### C. INSTRUMENTATION DEVELOPMENT

MANY ENVIRONMENTAL FACTORS, CREATED OR INFLUENCED BY METEOROLOGICAL CONDITIONS, CANNOT BE SUCCESSFULLY STUDIED AT THE PRESENT TIME BECAUSE OF A LACK OF ADEQUATE INSTRUMENTATION TO MEASURE THE METEOROLOGICAL FACTORS. IN THE CASE OF SOME METEOROLOGICAL PARAMETERS SUCH AS SOIL TEMPERATURE, SOIL MOISTURE, DESERT HUMIDITIES, PARTICULATE MATTER IN THE ATMOSPHERE, ETC., PRESENT-DAY METEOROLOGICAL INSTRUMENTATION IS FAR FROM SATISFACTORY FROM THE STANDPOINT OF ACCURACY AND RELIABILITY. ALSO, AUTOMATION OF EXISTING METEOROLOGICAL MEASUREMENTS IS AN URGENT REQUIREMENT IN ORDER TO FACILITATE THE COLLECTION AND ANALYSIS OF METEOROLOGICAL DATA FOR ENVIRONMENTAL STUDIES. ACTIVITIES WERE CONTINUED IN THE DEVELOPMENT OF NEW EQUIPMENT AND IN IMPROVEMENT AND AUTOMATION OF EXISTING EQUIPMENT FOR MEASURING OF THOSE METEOROLOGICAL PARAMETERS USED TO DESCRIBE OR STUDY THE ENVIRONMENT.

#### D. THE ELECTRONIC ENVIRONMENTAL TEST FACILITY

DURING FISCAL YEAR 1960, THE SIGNAL CORPS BEGAN IMPLEMENTATION OF THE INITIAL PHASES OF AN ELECTRONIC ENVIRONMENTAL TEST FACILITY TO BE LOCATED IN SOUTHERN ARIZONA. WHILE THIS FACILITY WILL BE USED PRIMARILY TO MEASURE AND STUDY THE ELECTRO-MAGNETIC ENVIRONMENT IN WHICH THE ARMY OPERATES, THE TERRAIN AND METEOROLOGICAL STUDIES NECESSARY TO SUPPORT THE STUDIES OF THE ELECTRO-MAGNETIC ENVIRONMENT WILL, AS A BY-PRODUCT, CONTRIBUTE TO THE ARMY'S ENVIRONMENTAL RESEARCH PROGRAM.

## 7. TRANSPORTATION CORPS

THAT PART OF THE TRANSPORTATION CORPS PROGRAM CLOSELY RELATED TO ENVIRONMENTAL RESEARCH IS CONDUCTED BY THE U.S. ARMY TRANSPORTATION ENVIRONMENTAL OPERATIONS GROUP (TREG) WHOSE MISSION IS TO "PROVIDE TRANSPORTATION SUPPORT FOR MILITARY ACTIVITIES IN DIFFICULT ENVIRONMENTS, AND TO CONDUCT OPERATIONS LEADING TO IMPROVEMENT OF DIFFICULT ENVIRONMENT CAPABILITIES." ACCOMPLISHMENTS IN THE NATURAL DIFFICULT ENVIRONMENTS ARE AS FOLLOWS:

A 5-YEAR ENVIRONMENTAL PROGRAM HAS BEEN DIRECTED TO TREG BY THE CHIEF OF TRANSPORTATION GIVING TREG A WORLD-WIDE SCOPE OF INVESTIGATION AND DEVELOPMENT OF TRANSPORTATION METHODS AND SYSTEMS IN DIFFICULT ENVIRONMENTS. THIS IS A CONTINUATION OF PAST PROJECTS.

### A. ARCTIC OPERATIONS

PROJECT LEAD DOG 59 (FIGS. 6 AND 7), A 1940 NAUTICAL MILE, 72-DAY SUSTAINED TRACTOR-SLED TRAIN EXPLORATION OF NORTHERN GREENLAND, WAS ACCOMPLISHED WITHOUT MISHAP. THE MISSION OF THIS EXPLORATION WAS TO MARK A TRAIL OVER THE ICE FROM CAMP TUTO TO NYEBOE LAND AND PEARY LAND, AND TO LOCATE DESCENT ROUTES FROM THE ICECAP TO THE ICE-FREE LAND AREAS AT THE EXTREME POINTS. A DESCENT WAS LOCATED INTO NYEBOE LAND, BUT PEARY LAND WAS A DIFFERENT STORY. THE LACK OF SNOW ON THE ICECAP ADJACENT TO PEARY LAND PREVENTED THE FILLING OF LOCAL CREVASSE SYSTEMS AND THE SWING WAS FORCED TO TURN BACK. HAD IT BEEN POSSIBLE TO ANTICIPATE THIS SITUATION, A LARGER QUANTITY OF EXPLOSIVES WOULD HAVE BEEN CARRIED ON THE EXPEDITION TO LOOSEN FILL MATERIAL. FIVE ARMY R&D AGENCIES ACCOMPANIED THE LEAD DOG SWING TO COLLECT SCIENTIFIC DATA: QMR&E, SIGNAL MET, TRECOM, SIPRE, AND HUMRO.

PROJECT FLYING FROG WAS AN AVIATION EXERCISE WITH THE MISSION OF STUDYING SEA ICE IN THE VICINITY OF NYEBOE LAND. THE AIRCRAFT, ONE L20, ONE U1A AND ONE H19, FURNISHED RECONNAISSANCE SUPPORT FOR LEAD DOG (FIG. 8) AS WELL AS FLYING AN AIR EVACUATION MISSION TO WARD HUNT ISLAND, N. W. T., IN ADDITION TO THE ASSIGNED MISSION.

THE OVERLAND TRAIN (FIG. 7) WAS OPERATED ON A SUSTAINED BASIS FOR THE FIRST TIME. THE TRAIN OPERATED BETWEEN CAMP TUTO, CAMP CENTURY, AND SITE 11, TRAVELING A TOTAL DISTANCE OF 2460 MILES AND HAULING 355 TONS OF CARGO.

THE 10-TON OFF-ROAD TRAILER WAS ALSO TESTED AND PROVED TO HAVE A GREAT ADVANTAGE OVER THE STANDARD 10-TON SLED BEING USED IN GREENLAND. THE BIG ADVANTAGE OF THE TRAILER WAS THAT IT REQUIRES ONLY ONE-FIFTH THE DRAWBAR EFFORT REQUIRED BY A SLED CARRYING A COMPARABLE LOAD.

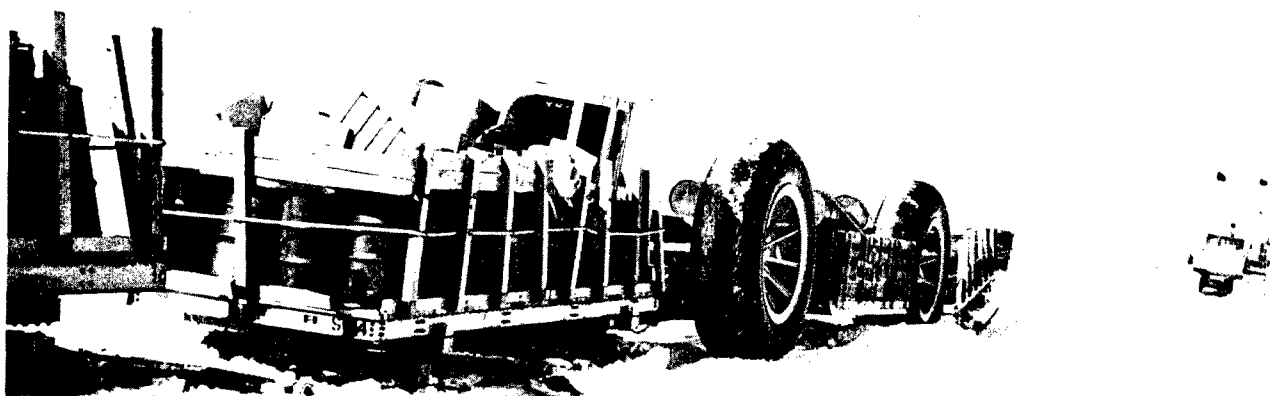


FIGURE 6. THE OLD AND THE NEW. 10 TON OTACO SLEDS AND 10 TON OFF-ROAD LARGE-WHEELED TRAILERS UTILIZED IN THE SAME TRACTOR SWING DURING LEAD DOG 59 OPERATIONS ON THE GREENLAND ICECAP.

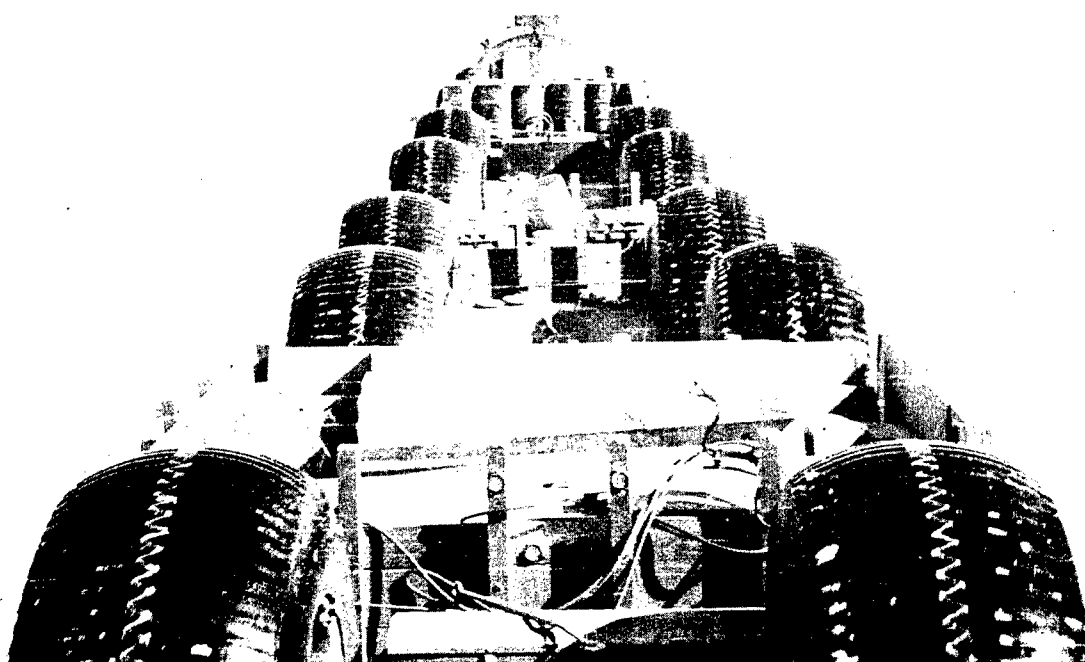


FIGURE 7. THE OVERLAND TRAIN ON THE GREENLAND ICECAP. THE OVERLAND TRAIN POINTS ITS NOSE TOWARD CAMP CENTURY DURING ITS 2460 MILE TEST OPERATION IN GREENLAND IN 1959.



FIGURE 8. PREFLIGHT PREPARATIONS. THE GREENLAND ICECAP TREG AVIATORS AND CREWMEN PREHEAT AN H19 HELICOPTER PRIOR TO A RECONNAISSANCE FLIGHT FOR OPERATION LEAD DOG 1959.

TREG Task Element, ANTARCTICA, CONSISTING OF AVIATION AND NAVIGATION PERSONNEL, SPENT UP TO 3 MONTHS IN ANTARCTICA COMPARING OPERATING DIFFERENCES BETWEEN THOSE PRACTICED BY TREG AND THE NAVY. A REPORT ON THIS ACTIVITY IS FORTHCOMING.

1960 IS ANTICIPATED TO BE TREG'S LAST BIG YEAR IN GREENLAND. EMPHASIS WILL BE PLACED ON TROPICAL, DESERT, ARCTIC, AND SUBARCTIC ENVIRONMENTS IN THE FUTURE.

#### B. SUBARCTIC OPERATIONS

A PRELIMINARY INVESTIGATION INTO THE MUSKEG ENVIRONMENT WAS MADE IN CENTRAL ALBERTA, CANADA, THROUGH THE COOPERATION OF THE CANADIAN OIL INDUSTRY. MOVEMENT OF HEAVY CARGO THROUGH MUSKEG REGIONS PRESENTS ONE OF THE MORE DIFFICULT MOBILITY PROBLEMS AND IS BEING PROGRAMMED AS A MAJOR AREA OF TREG STUDY.

TREOG SUPPORTED ARMY MANEUVERS IN ALASKA WITH OFF-ROAD TRAILERS AND TRAILER TECHNICAL REPRESENTATIVES. ALSO, AN OBSERVER VIEWED TRANSPORT PROBLEMS THAT OCCURRED DURING ONE PHASE OF THE MANEUVER.

#### C. DESERT OPERATIONS

TREOG Task Element, DESERT (FIG. 9), OPERATING AT CAMP IRWIN, CALIFORNIA, WAS INDOCTRINATED IN DESERT TRANSPORT PROCEDURES, MAINTENANCE, AND SURVIVAL. FOLLOWING THIS PHASE OF ORIENTATION, THE ELEMENT COMPARED DESERT AND CONVENTIONAL TIRES IN CROSS-COUNTRY MOBILITY, AND DAY-NIGHT OFF-ROAD MOTOR MOVEMENTS UTILIZING THE INFRA-RED BINOCULARS AND THE POSITION AND DIRECTION COMPUTER SUPPLIED BY ERDL.



FIGURE 9. TRUCK CONVOY ON SOFT SAND. AS A PART OF THE USA TREOG OPERATION DESERT TRAINING II THE TREOG Task Element CONDUCTED TRAINING IN DESERT DRIVING. THE TREOG CONVOY SHOWN ABOVE IS TRAVELING THROUGH A SOFT SAND AREA IN THE MOJAVE DESERT AT CAMP IRWIN, CALIFORNIA. THE LEAD TRUCK COMPACTS THE SURFACE WITH ITS TIRES AND THE REMAINING TRUCKS FOLLOW IN ITS TRACKS.

BIBLIOGRAPHY OF TECHNICAL PAPERS AND REPORTS

MILITARY PUBLICATIONS

1. ANSTEY, R.L., DIGITIZED ENVIRONMENTAL DATA PROCESSING, QMREC RSCH STUDY RPT RER-31, MAR 1960
2. BLAIR, W.B. AND CHAMBERS, J.V., CANAL ZONE ANALOGS VIII: ANALOGS OF CANAL ZONE CLIMATE IN AUSTRALIA AND NEW GUINEA, QMREC TECH RPT EP-113, JUL 1959
3. CHEMICAL WARFARE LABORATORIES, EFFECT OF ENVIRONMENTAL TEMPERATURE ON TOXICITY OF GB INTRAVENOUSLY ADMINISTERED, JAN 1960
4. DE PERCIN, F. AND PARMELE, O., FREQUENCY OF TEMPERATURES AT FORT GREELY, ALASKA, QMREC TECH RPT EP-122, JAN 1960
5. DE PERCIN, F., MICROCLIMATOLOGY OF A SUBARCTIC SPRUCE FOREST AND A CLEARING AT BIG DELTA, ALASKA, QMREC TECH RPT EP-130, (IN PRESS)
6. -----, THE SUMMER CLIMATE OF THE LAKE PETERS AREA, BROOKS RANGE, ALASKA, IN: PRELIMINARY REPORT OF THE MT. CHAMBERLIN-BARTER ISLAND PROJECT, ALASKA, MILITARY GEOLOGY BRANCH, U.S. GEOLOGICAL SURVEY, WASHINGTON, AUG 1959, PP 7-16
7. DODD, A.V., AND MCPHILIMY, H.S., YUMA SUMMER MICROCLIMATE, QMREC TECH RPT EP-120, NOV 1959
8. ENVIRONMENTAL PROTECTION RESEARCH DIVISION, SOUTHWEST ASIA: ENVIRONMENT AND ITS RELATIONSHIP TO MILITARY ACTIVITIES, QMREC TECH RPT EP-118, JUL 1959
9. HASTINGS, A.D., JR., METEOROLOGICAL OBSERVATIONS DURING EXERCISE CRYSTAL KEY I, CAMP FISTCLENCH, GREENLAND, SUMMER 1959, QMREC RSCH STUDY RPT RER-30, JUN 1960
10. MCGILL UNIVERSITY, TEMPERATURE AND WIND FREQUENCY TABLES FOR EURASIA, VOL 1, JAN-MAR, (FEB 1960) VOL 2 APR-JUNE (MAY 1960) VOL 3 JUL-SEP (JUN 1960), MONTREAL
11. PORTER, W.L. AND ROOS, N.H., OCCURRENCE OF HIGH TEMPERATURES IN YUMA STORAGE DUMPS, QMREC TECH RPT EP-121, NOV 1959
12. ROBINSON, CARROLL G., SURVEY AND ANALYSIS OF THE EFFECTS OF HUMIDITY ON ORDNANCE MATERIEL, SOUTHWEST RESEARCH INSTITUTE, JAN 1959 (ISSUED DECEMBER 1959)



13. ROBISON, W.C., THE MEASUREMENT AND SIGNIFICANCE OF DEW, QMREC RSCH STUDY RPT RER-28, SEP 1959
14. ROSS, CARL W., TABLE OF ALLOWANCES TA 21. CLOTHING AND EQUIPMENT. PART 6, CLOTHING ALLOWANCE ZONES. (REVISION), U.S. ARMY, ADJ GEN OFF, SEP 1959
15. SOUTHWEST RESEARCH INSTITUTE, THE APPLICATION OF WINDCHILL AS A METHOD OF DESCRIBING THE COOLING RATE OF EQUIPMENT. DEC 1958 (ISSUED AUGUST 1959)
16. SOUTHWEST RESEARCH INSTITUTE, PETROGRAPHIC AND PARTICLE SIZE ANALYSIS OF TERRAIN SAMPLES TAKEN FROM VEHICLE TEST COURSES AT YUMA TEST STATION, ARIZONA, AND ABERDEEN PROVING GROUND, MARYLAND, MAR 1959 (ISSUED AUGUST 1959)
17. THOMPSON, W.F., CANAL ZONE ANALOGS VII; ANALOGS OF CANAL ZONE CLIMATE IN INDONESIA, THE PHILIPPINES AND BORNEO, QMREC TECH RPT EP-116, JUN 1959
18. THOMAS, BENJAMIN E., TRANSPORTATION AND PHYSICAL GEOGRAPHY IN WEST AFRICA, SPECIAL TECH RPT PREPARED UNDER QMC CONTRACT DA19-129-QM-1309 THROUGH NATIONAL ACADEMY OF SCIENCES-NATIONAL RESEARCH COUNCIL, DEPT. OF GEOGRAPHY, UNIV OF CALIF AT LOS ANGELES, 1960
19. U.S. ARMY TRANSPORTATION ENVIRONMENTAL OPERATIONS GROUP, PRELIMINARY INVESTIGATION OF TROPICAL TRANSPORTATION, FT. EUSTIS, VIRGINIA, AUG 1959
20. U.S. ARMY WATERWAYS EXPERIMENT STATION, SOILS TRAFFICABILITY, ARMY TECHNICAL BULLETIN, ENGINEER 37, JUL 1959
21. WOOD, W.F. AND SNELL, J.B., PRELIMINARY INVESTIGATIONS OF A METHOD TO PREDICT LINE-OF-SIGHT CAPABILITIES, QMREC RSCH STUDY RPT EA-10, JUL 1959
22. -----, QUANTITATIVE SYSTEM FOR CLASSIFYING LANDFORMS, QMREC TECH RPT EP-124, FEB 1960

TECHNICAL PAPERS PRESENTED AT MEETINGS

23. ANSTEY, R.L., TOPOGRAPHIC INDICES OF CAVE LOCATION, NATIONAL SPELIOLOGICAL SOCIETY, BOSTON GROTTO, CAMBRIDGE, MASS., FEB 1960
24. -----, THE GEOGRAPHIC WORK OF LEWIS EVANS, ASSOCIATION OF AMERICAN GEOGRAPHERS, DALLAS, TEXAS, APR 1960

25. BRIERLY, W.B., RESUME OF APPLIED ENVIRONMENTAL RESEARCH IN THE TECHNICAL SERVICES OF THE ARMY, DEFENSE RESEARCH BOARD, DEPT OF NATIONAL DEFENSE, OTTAWA, ONTARIO, CANADA, 21 OCT 1959
26. LACKEY, E.E., A METHOD FOR ESTIMATING THE FREQUENCY DISTRIBUTION OF DAILY MINIMUM TEMPERATURES, ASSOCIATION OF AMERICAN GEOGRAPHERS, DALLAS, TEXAS, APR 1960
27. MEIGS, P., SOME GEOGRAPHIC FACTORS IN THE PELOPONNESIAN WAR, ASSOCIATION OF AMERICAN GEOGRAPHERS, DALLAS, TEXAS, APR 1960
28. MEYER, W.E., DeCAROLIS, J.J., AND ESPENSCHADE, P.W., THE STARTING OF DIESEL ENGINES AT VERY LOW TEMPERATURES, PROC. 1959 CONF. OF THE INTERN. CONG. OF COMBUSTION ENGINES, 15-20 JUNE 1959. WIESBADEN, WEST GERMANY
29. ROCK, C.G., JR., SPRING AND EARLY SUMMER CLIMATE, LAKE PETERS, ALASKA, 2ND ANNUAL PLANNING CONFERENCE, CAMBRIDGE, MASS., OCT 1959
30. ROBISON, W.C., THE SAVANNAS OF VIRGINIA, ASSOCIATION OF AMERICAN GEOGRAPHERS, DALLAS, TEXAS, APR 1960
31. SNELL, J.B., PRELIMINARY INVESTIGATIONS OF A METHOD TO PREDICT LINE-OF-SIGHT CAPABILITIES, AM. ASSN. ADV. OF SCIENCE, CHICAGO, ILL., DEC 1959
32. THOMPSON, W.F., DETERMINATION OF THE SPATIAL RELATIONSHIPS OF LOCALLY DOMINANT TOPOGRAPHIC FEATURES, AM. ASSN. ADV. OF SCIENCE, CHICAGO, ILL., DEC 1959
33. WOOD, W.F., PREDICTION IN TERRAIN ANALYSIS, AM. ASSN. ADV. OF SCIENCE, CHICAGO, ILL., DEC 1959
34. -----, QUALITATIVE CONSIDERATION IN QUANTITATIVE PHYSICAL GEOGRAPHY, SYMPOSIUM GEOGRAPHY DIVISION OF EARTH SCIENCE, NATIONAL RESEARCH COUNCIL, CHICAGO, ILL., MAY 1959

APPENDIX 1

DEPARTMENT OF THE ARMY  
GENERAL STAFF, UNITED STATES ARMY  
WASHINGTON 25, D.C.

CSGLD/F1 28507

10 JUNE 1949

MEMORANDUM FOR: CHIEF OF ORDNANCE  
CHIEF OF ENGINEERS  
CHIEF OF TRANSPORTATION  
CHIEF, CHEMICAL CORPS  
CHIEF SIGNAL OFFICER  
THE QUARTERMASTER GENERAL  
THE SURGEON GENERAL  
CHIEF, ARMY SECURITY AGENCY  
CHIEF, ARMY FIELD FORCES

SUBJECT: ASSIGNMENT OF RESEARCH AND DEVELOPMENT COGNIZANCE IN THE FIELDS  
OF CRYOLOGICAL PHENOMENA, METEOROLOGY, AND ENVIRONMENTAL RESEARCH

1. REFERENCES:

A. MEMORANDUM, THIS OFFICE, SUBJECT: "DEFINITION OF PRIMARY  
COGNIZANCE AS APPLIED TO RESEARCH AND DEVELOPMENT ACTIVITIES," DATED 24  
NOVEMBER 1948.

B. RDB 165/2.1 (WITH ATTACHMENTS) WHEREIN THE RDB ASSIGNED  
PRIMARY RESPONSIBILITY FOR RESEARCH AND DEVELOPMENT IN THE FIELD OF SNOW,  
ICE AND PERMAFROST ON AND BENEATH THE LAND SURFACE (EXCEPT THE LITTORAL)  
TO THE DEPARTMENT OF THE ARMY.

C. RDB 133/2, "STATEMENT OF POLICY AND ALLOCATION OF RESPON-  
SIBILITY FOR RESEARCH AND DEVELOPMENT PROGRAMS," AS SUPPLEMENTED BY  
RDB 133/3 AND RDB 133/4.

2. A. PRIMARY COGNIZANCE FOR RESEARCH AND DEVELOPMENT IN THE FIELD  
OF CRYOLOGICAL PHENOMENA PERTAINING TO SNOW, ICE AND PERMAFROST ON AND BE-  
NEATH THE EARTH'S SURFACE IS ASSIGNED TO THE CHIEF OF ENGINEERS. THIS  
ASSIGNMENT INCLUDES RESPONSIBILITY WITHIN THE NATIONAL MILITARY ESTABLISH-  
MENT FOR RESEARCH AND DEVELOPMENT PERTAINING TO CRYOLOGICAL PHENOMENA  
ON AND BENEATH THE LAND SURFACE (EXCEPT THE LITTORAL) AS ASSIGNED TO THE  
DEPARTMENT OF THE ARMY BY THE RESEARCH AND DEVELOPMENT BOARD IN REFERENCE  
1 B ABOVE.

CSGLD/F1 28507

SUBJECT: ASSIGNMENT OF RESEARCH AND DEVELOPMENT COGNIZANCE IN THE FIELDS OF CRYOLOGICAL PHENOMENA, METEOROLOGY, AND ENVIRONMENTAL RESEARCH

B. IN ADDITION TO THE RESPONSIBILITIES OUTLINED IN REFERENCE 1 A ABOVE, THE ADDITIONAL RESPONSIBILITIES OF THE DEPARTMENT OF THE ARMY AS SET FORTH IN PARAGRAPH 5 OF REFERENCE 1 C ABOVE ARE DELEGATED TO THE CHIEF OF ENGINEERS. THE CHIEF OF ENGINEERS WILL INSURE THAT ALL QUESTIONS OF INDIVIDUAL DEPARTMENTAL RESPONSIBILITY ARE EITHER SETTLED BY MUTUAL AGREEMENT, OR IN THE EVENT OF DISAGREEMENT, ARE SUBMITTED TO THE DEPUTY DIRECTOR FOR RESEARCH AND DEVELOPMENT FOR DECISION. DISAGREEMENTS TO SUCH DECISIONS WILL BE REFERRED BY THE PROPOSING DEPARTMENT TO THE RESEARCH AND DEVELOPMENT BOARD FOR RESOLUTION.

C. THE CHIEF OF ENGINEERS IS CHARGED WITH KEEPING THE DEPARTMENTS OF NAVY AND AIR FORCE FULLY ADVISED OF THE CURRENT STATUS AND PROGRESS IN THIS FIELD AND WILL MAINTAIN DIRECT LIAISON FOR THAT PURPOSE.

3. A. PRIMARY COGNIZANCE FOR RESEARCH AND DEVELOPMENT WITHIN THE RESPONSIBILITIES OF THE DEPARTMENT OF THE ARMY IN THE FIELD OF METEOROLOGY IS ASSIGNED TO THE CHIEF SIGNAL OFFICER. METEOROLOGY IS DEFINED AS THE SCIENCE OR THAT BRANCH OF PHYSICS WHICH TREATS OF THE PHYSICAL, CHEMICAL, AND ELECTRICAL PARAMETERS OF THE ENTIRE GASEOUS ENVELOPE OF THE EARTH, SUCH AS COMPOSITION, WIND, PRESSURE, TEMPERATURE, HUMIDITY, AND THE VARIOUS PHENOMENA ASSOCIATED THEREWITH, INCLUDING ALL THEORETICAL, SYNOPTIC AND INSTRUMENTAL ASPECTS OF THE SAME. THIS ASSIGNMENT DOES NOT INCLUDE THE APPLICATION OF METEOROLOGICAL DATA TO NON-METEOROLOGICAL TECHNIQUES, SUCH AS SOUND-RANGING, ELECTRO-MAGNETIC WAVE PROPAGATION, AND SPECIALIZED ENVIRONMENTAL STUDIES EXCEPT WHEN SUCH TECHNIQUES ARE USED AS METEOROLOGICAL TOOLS.

B. NO ASSIGNMENT OF RESEARCH AND DEVELOPMENT RESPONSIBILITY FOR THE SUBJECT FIELD HAS BEEN MADE BY THE RESEARCH AND DEVELOPMENT BOARD.

4. A. PRIMARY COGNIZANCE FOR RESEARCH AND DEVELOPMENT WITHIN THE RESPONSIBILITIES OF THE DEPARTMENT OF THE ARMY IN THE FIELD OF APPLIED ENVIRONMENTAL RESEARCH IS ASSIGNED TO THE QUARTERMASTER GENERAL. APPLIED ENVIRONMENTAL RESEARCH IS DEFINED AS THE COLLATION OF STATISTICAL, METEOROLOGICAL, CLIMATIC, AND GEOGRAPHICAL DATA AS ACCUMULATED BY THE RESPONSIBLE AGENCIES, THE INTERPRETATION OF THESE DATA, AND THE PRESENTATION OF THE EVALUATED INFORMATION IN SUITABLE FORM FOR APPLICATION BY APPROPRIATE AGENCIES TO LOGISTICS PROBLEMS OF EQUIPMENT, PERSONNEL AND OPERATIONAL FUNCTIONS. THIS ASSIGNMENT EXCLUDES THE FIELD OF SNOW, ICE AND PERMAFROST AS COVERED BY PARAGRAPH 2 A ABOVE.

B. NO ASSIGNMENT OF RESEARCH AND DEVELOPMENT RESPONSIBILITY FOR THE SUBJECT FIELD HAS BEEN MADE BY THE RESEARCH AND DEVELOPMENT BOARD.

CSGLD/F1 28507

SUBJECT: ASSIGNMENT OF RESEARCH AND DEVELOPMENT COGNIZANCE IN THE FIELDS  
OF CRYOLOGICAL PHENOMENA, METEOROLOGY, AND ENVIRONMENTAL RESEARCH

5. THE WAR DEPARTMENT RESEARCH AND DEVELOPMENT PROGRAM FOR FISCAL  
YEAR 1959, THE DEPARTMENT OF THE ARMY RESEARCH AND DEVELOPMENT PROGRAM  
FOR FISCAL YEAR 1950, AND THE DEPARTMENT OF THE ARMY RESEARCH AND  
DEVELOPMENT PLAN FOR FISCAL YEAR 1951 ARE AMENDED ACCORDINGLY.

BY ORDER OF THE UNDER SECRETARY OF THE ARMY:

C. G. HELMICK  
MAJOR GENERAL, GSC  
DEPUTY DIRECTOR FOR  
RESEARCH AND DEVELOPMENT  
LOGISTICS DIVISION

APPENDIX 2

FILE NO.  
G4/F2

41949

SUBJECT: TRANSFER OF SIX ARMY-WIDE  
ENVIRONMENTAL RESEARCH PROJECTS  
TO THE QUARTERMASTER GENERAL

TO THE QUARTERMASTER GENERAL FROM G4 DATE 30 JUN 1952 COMMENT NO. 1  
ATTN: MILITARY PLANNING DIVISION DR. PAUL A. SIPLE/53665/KJW  
RESEARCH AND DEVELOPMENT BRANCH

1. AN EVALUATION OF THE ENVIRONMENTAL RESEARCH PROGRAMS OF THE ARMY REVEALS THAT SEVERAL REQUIREMENTS EXIST WITHIN FIELDS OF COGNIZANCE ASSIGNED TO YOU WHICH ARE NOT CURRENTLY INCLUDED IN ANY PROGRAM. THEY ARE:

A. RESEARCH ON TECHNIQUES OF APPLICATION OF ENVIRONMENTAL KNOWLEDGE TO ARMY-WIDE MILITARY PROBLEMS.

B. SUPPORT OF ENVIRONMENTAL AND GEOGRAPHIC RESEARCH ON GEOGRAPHIC EXPEDITIONS AND OTHER FIELD PROJECTS NOT SPECIFICALLY ORGANIZED BY AGENCIES OF D/A. THE INTERESTS OF ALL D/A AGENCIES ARE INCLUDED IN THIS PROJECT. THIS FINANCIAL SUPPORT DOES NOT CONFLICT WITH EXISTING POLICIES FOR EXPEDITION SUPPORT BUT IS SUPPLEMENTARY TO THEM.

C. ESTABLISHMENT OF RAPID SYSTEM FOR THE ANALYSIS OF PERFORMANCE OF ARMY EQUIPMENT UNDER ALL ENVIRONMENTAL CONDITIONS FOLLOWING THE PRINCIPLES OF RECOMMENDED IN ORO-R-4, DATED 12 JULY 1950, (PROJECT ENVANAL).

D. DEVELOPMENT OF A SYSTEM WHEREBY MILITARY AREAS CAN BE ANALYZED IN TERMS OF ENVIRONMENTAL STRESSES, AND RESULTS ORGANIZED IN A FORM ADAPTABLE TO MACHINE TABULATION. THIS WILL BE THE BASIC INFORMATION AGAINST WHICH THE PERFORMANCE OF ARMY EQUIPMENT WILL BE EVALUATED BY THE RAPID SYSTEM IN C ABOVE, PERMITTING A REGIONAL EVALUATION OF THE CAPABILITIES OF MILITARY EQUIPMENT IN THE FORM OF LOGISTICS AND OPERATIONS ALMANACS.

E. PREPARE RECOMMENDED D/A POLICIES ESTABLISHING DESIGN CRITERIA FOR PERFORMANCE OF ARMY EQUIPMENT AND MATERIAL UNDER ADVERSE CONDITIONS OF ENVIRONMENT SIMILAR TO SR 705-70-5.

F. RESEARCH ON RADICAL METHODS OF IMPROVEMENT IN PROTECTION OF PERSONNEL FROM ENVIRONMENTAL STRESSES. THIS PROJECT IS INTENDED TO SUPPORT NEW SCIENTIFIC CONCEPTS WHICH IF SUCCESSFUL, MAY BE IMPORTANT, BUT PRACTICABILITY OF APPLICATION CANNOT BE ASSURED FROM PRESENT KNOWLEDGE OF THE SUBJECT.

2. THE RESPONSIBILITY FOR CONDUCTING RESEARCH ON THESE PROBLEMS IS HEREBY ASSIGNED TO THE QUARTERMASTER GENERAL.

3. FUNDS IN THE AMOUNT OF \$479,000 HAVE BEEN INCLUDED IN THE FY 1953

G4/F2

SUBJECT: TRANSFER OF SIX ARMY-WIDE ENVIRONMENTAL RESEARCH PROJECTS  
TO THE QUARTERMASTER GENERAL

ARMY-WIDE RESEARCH BUDGET TO COVER THESE PROJECTS. A SIMILAR AMOUNT IS INCLUDED IN THE FY 1954 ARMY-WIDE RESEARCH BUDGET FOR CONTINUANCE OF THESE PROJECTS. SUBSEQUENT FUNDING ACTIONS ON BUDGETS BEYOND FY 1954, ARE THE RESPONSIBILITY OF YOUR OFFICE. UPON AVAILABILITY, FUNDS REFERRED TO WILL BE TRANSFERRED TO THE QUARTERMASTER GENERAL. THE ASSIGNMENT OF TECHNICAL OBJECTIVES AND DIVISION FUNDS IS AS FOLLOWS:

<u>PROJECT NO.</u>	<u>TITLE</u>	<u>TECHNICAL OBJECTIVE</u>	<u>BUDGET PROJECT</u>	<u>FUNDED IN FY 1953</u>
*A. OX8305001Z	RESEARCH ON APPLICATIONS OF ENVIRONMENTAL TECHNIQUES	10-16	1520	\$50,000
B. OX8303002Z	SUPPORT OF ENVIRONMENTAL AND GEOGRAPHIC RESEARCH ON GEOGRAPHIC EXPEDITIONS AND OTHER FIELD PROJECTS NOT SPECIFICALLY ORGANIZED BY AGENCIES OF D/A.	10-16	1520	\$100,000
C. OX8305002Z	ESTABLISHMENT OF MACHINE TABULATION SYSTEM OF RECORDING EQUIPMENT PERFORMANCE UNDER SPECIFIC CONDITIONS OF THE ENVIRONMENT (ENVANAL)	10-16	1520	\$150,000
D. OX8303001Z	DEVELOPMENT OF TECHNIQUES AND ESTABLISHMENT OF GEOGRAPHIC BASE FOR "LOGISTICS AND OPERATIONS ALMANACS."	10-16	1520	\$100,000
E. OX8301001Z	RESEARCH FOR ESTABLISHMENT OF ARMY-WIDE ENVIRONMENTAL DESIGN CRITERIA STANDARDS	10-16	1520	\$29,000
F. OX8301005Z	RESEARCH ON AND DEVELOPMENT OF RADICAL IMPROVEMENTS IN ENVIRONMENTAL PROTECTION OF PERSONNEL	10-16	1520	\$50,000

\*THIS IS A CONTINUATION OF FY 1952 PROJECT PREVIOUSLY TRANSFERRED TO YOUR OFFICE.

G4/F2

SUBJECT: TRANSFER OF SIX ARMY-WIDE ENVIRONMENTAL RESEARCH PROJECTS  
TO THE QUARTERMASTER GENERAL

4. DUE TO THE ARMY-WIDE INTEREST IN THESE PROJECTS, MONITORSHIP WILL BE MAINTAINED BY GENERAL STAFF. THE PRIMARY CONTACT FOR GENERAL STAFF IS DR. PAUL A. SIPLE, OACofS, G-4, RESEARCH AND DEVELOPMENT DIVISION, RESEARCH BRANCH, (CHAIRMAN, DEPARTMENT OF THE ARMY COMMITTEE ON ENVIRONMENTAL FACTORS AND CONTROL). COORDINATION WITH INTERESTED AGENCIES WILL BE MAINTAINED BY THE PROJECT OFFICER, OQMG.

5. BACKGROUND DATA PERTAINING TO THESE PROJECTS IS LOCATED IN DR. SIPLE'S OFFICE, ROOM 3B-480, THE PENTAGON, AND ARE AVAILABLE TO YOUR PERSONNEL FOR INSPECTION AND TRANSFER, IF DESIRED.

6. IT IS REQUESTED THAT STEPS BE TAKEN AT THIS TIME TO INITIATE FORMAL PROJECTS FOR INCLUSION IN YOUR RESEARCH AND DEVELOPMENT PROGRAM.

/s/ MICHAEL BUCKLEY, JR.  
COLONEL, GS  
ASST. DEP. ACOFS, G-4, FOR  
RESEARCH & DEVELOPMENT



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